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Contents of Volume 19, No. 2, 1982

INDEX TO AUTHORS

The following papers appeared in the last issue of Fishery Technology

Contents of Volume 19, No. 1, 1982

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1–7–1982

Observations on the Parasites and Associates of Wood Boring Molluscs and Crustaceans of the South-West Coast of India

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An interesting assemblage of commensalic organisms ranging from Protozoa to Arthropoda have been identified from the wood boring animals from the south-west coast of India. Certain aspects of the general biology of the associated ciliates such as the nature of incidence, division in relation to environmental parameters, survival outside the body of the host and reactions related to the general condition of the host are described. Results are also presented of the tolerance of the rare commensalic hydroid *Eutima commensalis* to different salinities of the medium.

The importance of the preservation of timber structures against the attack of marine boring organisms has been recognised in India for some time and a large volume of information has accumulated regarding the taxonomy and biology of these pests. But very little work has been carried out on the organisms associated with these timber destroying animals in spite of the possible potential of certain parasites and predators as biological control agents of wood boring animals.

Although several organisms are associated with timber boring animals in their natural habitat (Clapp & Kenk, 1963), nothing more than mere reporting of the causal occurrence of these associates has been done so far and the real cause and effect relationship has unfortunately not been established even in a single instance. Therefore, in the present study an attempt has been made to examine: (1) the nature of the organisms associated with the wood boring organisms along the coast of India, and (2) certain aspects of their biology.

Materials and Methods

The host animals were collected from submerged wooden piles, fenders, discarded country canoes, deal wood boxes, and also from test panels installed at different localities along the south-west coast of India. For preparing permanent mounts of ciliates, smear method was used since this produced little distortion of the organisms. The fixing agents used were: Schaudin's, Bouin's, Zenker's, 4% formaldehyde and Da Fano's cobalt nitrate formalin. Among the various stains employed the following produced best results. Delafields haematoxylin, Heidenhains iron alum-haematoxylin, Ehrlich's haematoxylin and Mallory's triple connective tissue stain. Of the silver impregnation techniques that of Chatton & Lwoff's as modified by Corliss (1953) and Klein (1958) was successful for ciliates.

For observation on the division of ciliates within the host in relation to water propulsion, test panels were installed, one set below the low water mark ('bottom' panel) and the other at the mid-tide level (intertidal' panel), so much so, the former was always submerged in water while the latter was subjected to periodic submersion and emersion.

Results and Discussion

The wood boring molluscs represented in the area are eight species of shipworms (Nair & Saraswathy, 1971) of which two, namely *Nausitora hedleyi* Schepman and *Teredo furcifera*, *Martesia striata* (Linnaeus) and *M. fragilis* (Verril and Bush) of which the former are the most destructive in the estuarine localities of the south-west coast of India. Of the wood boring crustaceans

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only the isopods have so far been collected from this area. Of these, the pillbugs are most important. They are *Sphaeroma terebrans* Bate, *S. annandalei* Stebbing, *S. annandalei* var *travancorensis* Pillay, *S. walkeri* Stebbing and *S. triste* Heller.

Along the Indian coasts, the organisms associated with wood boring animals are a heterogenous assemblage consisting of at least fifteen species of ciliates, two species of hydroids, three species of ectoprocts, six species of annelids and eleven species of arthropods.

An interesting assemblage of commensalic organisms, ranging from protozoa to arthropoda have been found in the wood boring molluscs (Fig. 1). For example,

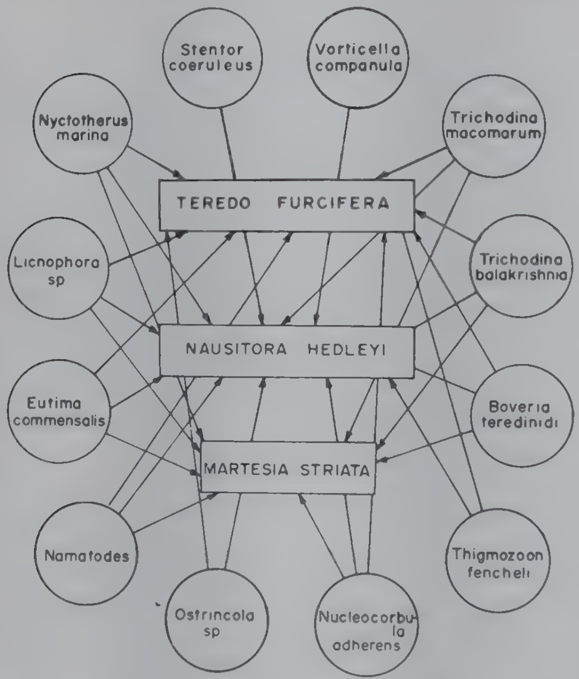

Fig. 1. Commensals of wood-boring molluscs *Teredo furcifera, Nausitora hedleyi* and *Martesia striata*

the Protozoa is represented by *Nucleocorbula adherens* Santhakumari and Nair, *Boveria teredinid* Pickard, *Thigmozoon fencheli* Santhakumari and Nair, *Trichodina balakrishnia* Santhakumari and Nair, *T. macomarum* Raabe and Raabe, *Nyctotherus marina* Santhakumari and Nair, *Stentor coeruleus* Ehrenberg, *Licnophora* sp. and *Vorticella companula* Ehrenberg. The coelenterates are represented by a single but highly interesting species, the hydroid *Eutima commensalis* Santhakumari implanted in the ctenidia of these wood boring molluscs. The cyclopoid copepod *Ostrincola* sp. has been noticed living on the gills of the shipworm *Nausitora hedleyi.* Besides these, a large number of as yet unidentified nematodes and turbellarians have been found in close association with the shipworms.

From the wood boring crustaceans only ectocommensals have so far been collected (Fig. 2). These consists chiefly of ciliates namely *Vorticella companula Ehrenberg, Zoothamnium rigidum* Precht, *Cothurnia gammari* Precht, *Lagenophrys cochinensis* sp. nov., *Epistylis gammari* Precht, *Folliculina producta* (Wright), and *F. boltoni* Kent. The only hydroid noticed on *Sphaeroma terebrans* is *Clytia hendersonae* Torrey. The interesting ostracod *Microsyssitria indica* Hart, (Nair and Hart) is found in association with *S. terebrans.* So also the isopod *Iais singaporensis* Menzies has been noticed over the surface of the body and also in the burrows of *S. terebrans.* Harpacticoid copepods (as yet unidentified) have also been seen in association with this wood boring isopod. The bryozoans are represented by three species, namely, *Electra*

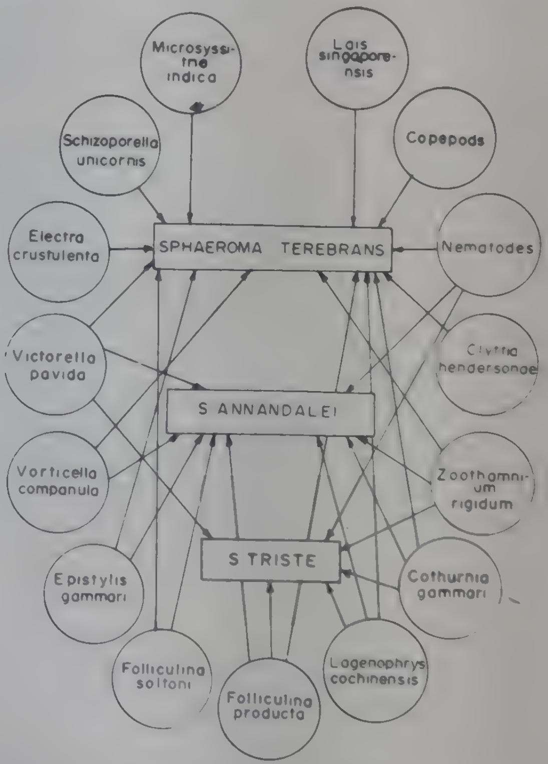

Fig. 2. Commensals of wood-boring crustaceans *Sphaeroma terebrans, S. annandalei* and *S. triste*

crustulenta (Pallas), *Victorella pavida* Kent, *Bowerbankia gracilis* Leidy. Besides, several nematodes have also been met with.

Yet another set of associates, most of them possibly predators has been noticed living in the burrows of the wood-boring mulluscs (Fig. 3). They are chiefly polychaetes such as *Lepidonotus tenuisetosus* (Gravier) *Eurythoe parvecarunculata* Horst,

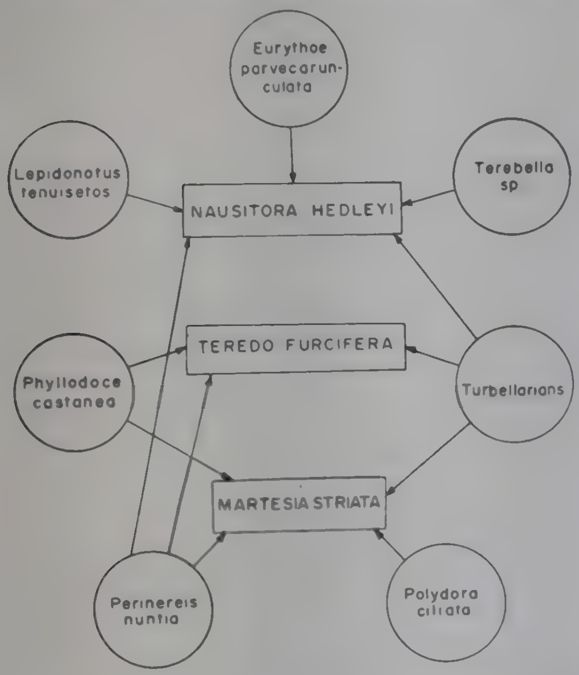

Fig. 3. Predators, scavengers and/or associate from the burrows of the wood-boring molluscs *Nausitora hedleyi, Teredo furcifera* and *Martesia striata*

Phyllodoce castanea (Marenzeller), *Perinereis nuntia* var *brevicirris* (Grube), *Polydora ciliata* Johnston, and *Terebella* sp.

Further a set of casual crustacean associates has been noticed along with sphaeromids in submerged infested wood (Fig. 4). They are *Tanais philetaerus* Stebbing, *Cirolana* willeyi Stebbing, and *Corophium triaenonyx* Stebbing.

Most investigations conducted so far on the associated organisms of wood boring animals have been purely descriptive in nature and it is only recently that these have been subjected to experimentation.

As part of a study of the general biology of the ciliates of wood boring molluscs, the nature of division of five species within

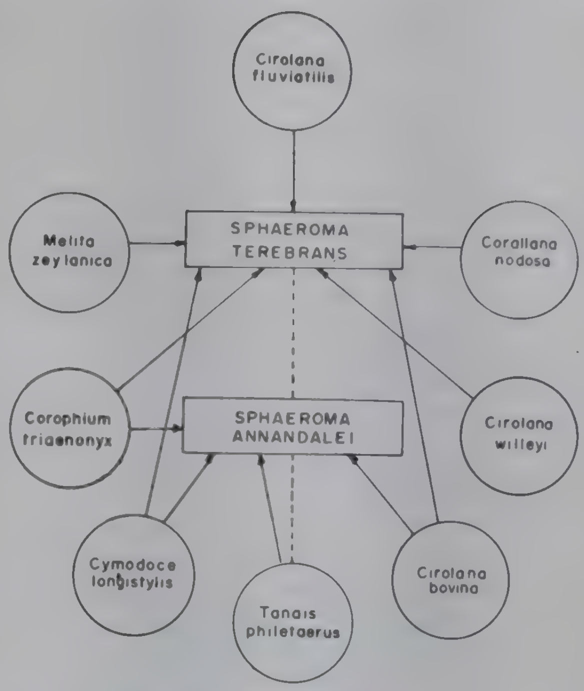

Fig. 4. Crustacean associate of *Sphaeroma terebrans* and *Sphaeroma annandalei*

the host has been examined in relation to such physical factors of the environment as tidal conditions and cycles of water propulsion. In the mantle cavity of the bivalve during the period of normal activity, there will be a constant flow of water. This physiological current of water contains fine suspended particles which can be used as food and also oxygen for the respiration of the bivalve. Since the ciliates live within the mantle cavity of the host, the question arises as to whether any of the physiological or morphogenetic activities of the ciliates are correlated with the cycles of water propulsion and food intake. Therefore the occurrence, relative abundance and morphogenetic condition of the respective species of ciliates within the body of the host under the varied conditions of activity were noted during the pre-monsoon period (February to May) in *Teredo furcifera* and during the monsoon period (June to September) in *Nausitora hedleyi*.

The results presented in Tables 1 and 2 show that (1) *Boveria teredinidi* is by far the most common species in regard to the number of individuals represented in the host followed in order by *Trichodina balakrishnia* and *Nucleocorbula adherens;* and

Table 1. *Relation between the number and division of associated ciliates, the size of the host (Teredo furcifera) and the tidal conditions during the pre-monsoon period (February-May, 1966) at the pier of the Oceanographic Laboratory*

No. of shipworms examined	Range in length mm. of shipworm	Panels from which shipworms were collected	Total number, average of ciliates and total number and percentage of dividing ciliates of the 5 species																			
			Nucleocorbula adherens				*Boveria teredinidi*				*Trichodina balakrishnia*				*Thigmozoon fencheli*				*Nyctotherus marina*			
			Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division	Total no. in shipworm	Average no. per shipworm	Total no. in division	Percentage in division
14	6–8	Inter-tidal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	6–8	Bottom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	8–20	Inter-tidal	1509	48.8	62	4.1	2960	80	33	1.1	3098	83.7	28	0.9	79	2.1	1	1.3	0	0	0	0
39	8–20	Bottom	1567	40.2	61	3.9	3159	81	38	1.2	3281	84.1	30	0.7	98	2.5	0	0	0	0	0	0
40	20–50	Inter-tidal	2048	51.2	91	4.4	7696	192.4	118	1.5	6364	159.1	92	1.4	237	5.9	5	2.1	78	4.6	2	2.6
42	20–50	Bottom	2143	51.0	93	4.3	8102	190.9	121	1.5	6825	162.5	93	1.3	244	5.8	6	2.5	202	4.8	5	2.5
17	50–75	Inter-tidal	748	44.0	23	3.0	2810	165.3	65	2.0	3233	190.2	41	1.2	76	4.5	1	1.3	101	5.1	3	2.9
21	50–75	Bottom	913	43.5	29	3.2	3492	166.3	58	1.8	4051	192.8	76	1.9	99	4.7	2	2.0	133	6.3	4	3.0

Table 2. *Relation between the number and division of associated ciliates, the size of the host, (Nausitora hedleyi) and tidal conditions during the monsoon period (June-September 1966) at the pier of the Oceanographic Laboratory*

			Total number, average of ciliates and total number and percentage of dividing ciliates of the 5 species																			
			Nucleocorbula adherens				*Boveria teredinidi*				*Trichodina balakrishnia*				*Thigmophrya fencheli*				*Nyctothereus marina*			
No. of *Nausitora* examined	Range in mm length of *Nausitora*	Panels from which *Nausitora* collected	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no. in division	Percentage in division	Total no. in *Nausitora*	Average no. per *Nausitora*	Total no in division	Percentage in division
23	9–40	Inter-tidal	1594	69.3	24	1.5	6465	281.1	34	0.5	6075	264.1	25	0.4	19	0.9	0	0	14	0.6	0	0
24	9–40	Bottom	1786	74.4	26	1.4	6817	284.0	29	0.4	5563	231.8	23	0.4	21	0.9	0	0	18	0.8	0	0
59	40–80	Inter-tidal	9257	156.9	192	2.1	41087	696.4	357	0.9	35357	599.3	201	0.5	121	2.1	0	0	172	2.9	0	0
56	40–80	Bottom	8803	157.2	179	2.0	39066	697.6	343	0.8	34328	613.0	224	0.6	134	2.2	0	0	158	3.8	0	0
42	80–125	Inter-tidal	11802	281.0	295	2.5	57259	1363.3	587	1.0	58572	1154.1	537	1.1	127	3.0	1	0.8	163	3.8	1	0.6
43	80–125	Bottom	12797	297.6	344	2.6	58523	1361.0	602	1.0	49526	1151.8	516	1.0	139	3.2	2	1.4	177	4.1	2	1.1
24	125–170	Inter-tidal	3291	137.1	68	2.0	12261	510.9	124	1.0	8772	365.5	85	0.9	51	2.1	0	0	59	2.9	1	1.6
25	125–170	Bottom	3588	143.5	103	2.9	11802	472.1	137	1.2	9348	373.9	96	1.0	53	2.1	1	1.7	64	2.9	0	0

(2) Ciliates do not occur in *Teredo furcifera* which belong to lower length groups suggesting that there is a time lag for the establishment of these commensals during the growth in length of the host.

A scrutiny of the values shown against the different panels namely those that were permanently submerged (bottom panels) and those subjected to periodic emergence and submergence (intertidal panels) suggests the following conclusions:

(1) A significant difference in the average number of ciliates in the two categories of blocks is not evident albeit slight differences in the number of the respective species represented.

(2) With reference to ciliates in division also the trend is almost the same in both the hosts with the exception that the percentage of *Nucleocorbula adherens* in division in *Teredo* is significantly higher than that in *Nausitora*. These observations are in conformity with those obtained by Beers (1959) for *Conchophthirus mytili* in which growth and division are found to be continuous and quite independent of water propulsion and tidal condition rather than rhythmic processes.

The results in Table 2 suggest that a larger number of *Nyctotherus marina* than *Thigmozoon fencheli* occurs in *Nausitora hedleyi*. In general each species is represented in much greater numbers in *N. hedleyi* than in *Teredo*. This suggests the possibility of two factors in the nature of incidence of the ciliates namely: (1) A bigger host species is likely to contain a greater number of associated organisms than a smaller host species; and (2) A low salinity is apparently tolerated to a greater extent than high salinities.

Since the ability of these ciliates to survive in sea water is related to the infection of new hosts, it was thought worthwhile to investigate the period they can remain in the ambient water outside the body of the host. The results of tests conducted in this connection (Table 3) indicate that the rate of survival of the five species of ciliates show significant variations. All the species except *Nyctothereus marina* seem to have the ability to live freely and in a healthy condition outside the body of the host for as long a period as six hours (on the basis of 50% survival). An interval of about 24 h seems to be reasonably adequate for a significant number of these to be ingested along with the inhalant current of water by a host and thus reach their normal habitat. Chances

Table 3. *Survival of 5 species of ciliates in sea water outside the body of the host. Nauistora hedleyi when kept under laboratory conditions*

	Nucleocorbula adherens		*Boveria teredinidi*		*Trichodina balakrishnia*		*Thigmozoon fencheli*		*Nyctotherus marina*	
Time in hours	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival	Nr. survived	Percentage of survival
2	20	100	72	100	55	100	18	100	12	92.3
4	16	80	69	95.8	53	96.4	16	88.8	9	69.2
6	10	50	61	84.7	48	87.3	13	72.2	4	30.8
24	5	25	27	37.5	24	43.6	7	38.8	0	0
30	4	20	20	27.8	17	30.9	2	9.0	0	0
48	3	15	7	9.7	9	16.3	0	0		
54	1	5	3	4.2	5	9.0	0	0		
72	0	0	0	0	0	0				

Table 4. *Survival of the hydroid of Eutima commensalis after varying periods of exposure to different grades of salinities*

Duration of exposure (h)	No. of colonies	Concentration of sea water in parts per thousand 0	5	10	15	17	20	25	30	35
1	5	2	3	4	4	5	4	4	4	4
2	5	1	2	4	5	5	5	5	4	4
6	5	1	2	5	5	5	5	4	3	3
18	5	1	1	5	5	5	5	2^{3} (1 colony)	2	2
24	5	1	1	4	5	5	4	2	2	1
42	5	1	1	3	3^{4} (part of a colony)	5	3^{4} (1 colony)	1	1	1
72	5	1	1	2	3^{4} (part of (a colony)	5^{4} (1 colony)	2^{1} (1 colony)	1	1	1
96	5	1	1	2	2^{3} (part of a colony)	4^{3} (1 colony)	2^{3} (part of a colony)	1	1	1

Numbers in paranthesis refer to number of colonies at each survival index level

Table 5. *The relation between size and shape of the colony and polyp and the salinity of the ambient water*

Month	Average salinity	No. of colonies examined	Range in nr. of polyps	Range in nr. of gonophores	Length of the polyp μ	Diameter of the polyp μ	Length of the tentacle μ	Height of the hypostome μ	Width of inter-tentacular membrane μ	Diameter of basal disc μ
November 1965	15.92	18	1–39	1–20	1218.75	112.5	500	81.25	62.5	688
December	22.41	20	1–34	1–9	968.75	112.5	343.75	37.5	37.5	375
January 1966	28.01	17	1–14	1–3	725	112.5	325	31.25	31.25	375
February	30.17	16	1–9	1–2	437.7	112.5	187.5	31.25	25	312.5
March	31.62	18	1–6	1–2	375	93.75	137.5	25	25	312.5
April	32.04	16	1–4	One	375	93.75	125.5	25	25	312.5

of such a possibility seem to be fair in the host's habitat which is a typical, shallow tropical estuary. Whereas in a steady current such forms are carried in one direction only, the oscillatory currents of an estuary have the advantage of dispersing them widely in different directions along the coast. These forms, even if carried out of this habitat on the ebb tide have again an opportunity within a period of about 6 h to be carried back to the habitat along with the flood tide and possibly find entry into some of the large and dense population of their hosts that occur in closely set batteries in underwater timber structures all along the water front. Nevertheless, the period of survival of most of these ciliates in a healthy condition in sea water outside the body of the host in the warm waters of the tropics is relatively short, varying from about 6 to 24 h. Of course a few of them do survive for longer periods but the nature of their behaviour indicates a general slackening of their swimming abilities followed by a tendency to sink to the bottom, to adhere loosely to any substratum and at times to slowly creep over it. Under these circumstances chances of ingestion of these by a shipworm along with the inhalant current of water seem to be distinctly limited. During their sojourn outside the body of the host, some are likely to be killed as a result of predation by other forms. Large quantities of water ebb and flow twice daily in this habitat where the tidal range is about 1 m. Despite these factors, it is interesting to note heavy infection of shipworms by these ciliates in this locality. The apparent inability of *Thigmozoon fencheli* and *Nyctotherus marina* to live in sea water outside the body of the host for a longer period than the other three species studied, seems to be a distinct disadvantage for these, from the stand point of survival. This is, indeed, reflected in their occurrence and relative abundance in the host body, being much less than the other three species.

Observations also indicate that these ciliates have the ability to desert the body of the host when conditions become unfavourable. Some are likely to be flushed out of the body of the host in the physiological current of water. Many are likely to be released on the death of the host through natural causes. This is specially so in crowded situations where, as a result of the depletion of the substratum, mass mortality takes place among shipworms. From the present set of tests, it is clear that these ciliates do possess the ability to exist for varying periods of time outside the body of the host and under the peculiar conditions of the estuarine habitat at least a few are likely to reach the body of fresh individuals. The loss sustained in great numbers can be offset by the rapid multiplication which may facilitate continued survival in the body of the host. It is also not improbable that the escape of large number of individuals into the medium may to some extent compensate for the brief period of survival so much so a relatively constant number of individuals is presumably maintained in the area from where they can get injested by new hosts.

Yet another interesting observation during this test was regarding the nature of the relationship between the hosts and their associates. It is clear that these associates apparently need a healthy host for their normal existence and activities, any stress on the host seems to be a stress on the associates as well. This is evident from the fact that shipworms subjected to the physical stress of exposure to the air and thus prevented from normal siphoning are found on subsequent examination to be comparatively free from the free living types of associates. These have obviously deserted their host most probably on account of adverse conditions in their habitat. Even in this behaviour, variations are evident in respect to the different species. For example a noticeable reduction in the number of *Nucleocorbula adherens, Boveria teredinidi* and *Trichodina balakrishnia* is evident even after two hours of exposure. But in the case of *Thigmozoon fencheli* and *Nyctotherus marina* this is evident only after 6 h. It is interesting to recall in this connection the fact that *T. fencheli* and *N. marina* are species with least ability to survive in sea water outside the body of the host. These conclusions if proved are significant and indicate that most of these ciliates are apparently harmless commensalic forms living within the mantle cavity which affords considerable protection for these organisms.

Since information on the physiological activities of commensalic organisms in general

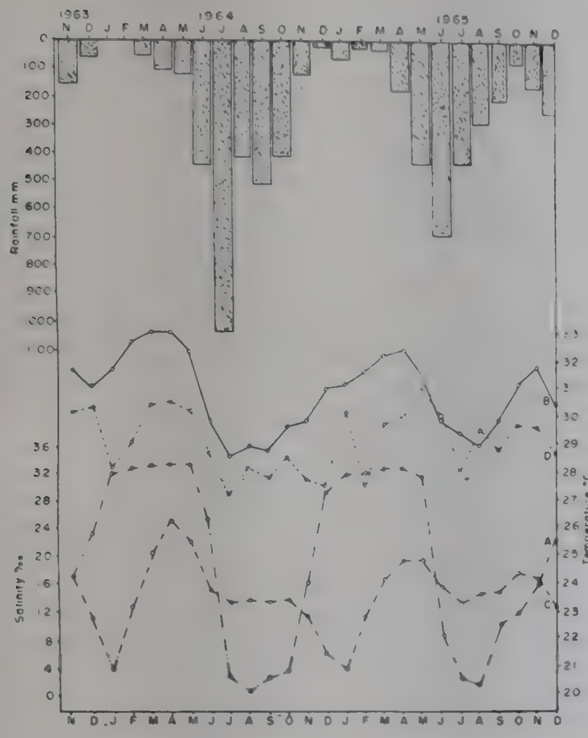

Fig. 5. Hydrographic conditions of Cochin harbour
A-Average salinity; B-Average maximum atmospheric temperature C-Average minimum atmospheric temperature; D-Average water temperature

and that of timber destroying organisms in particular of tropical estuarine habitats is lacking, studies were conducted to observe the reactions of a very interesting commensalic species of hydroid, *Eutima commensalis* Santhakumari to different salinities of the medium. This species was specially chosen on account of its appearance in the estuary during the post-monsoon period when the salinity shows an upward trend (Fig. 5) and its continued existence throughout the period of the post-monsoon as well as the pre-monsoon until about June and its apparent disappearance from its host during June consequent on the onset of heavy rains. This suggested the overriding influence of salinity of the medium on this organism.

The results presented in Table 4 reveal that *Eutima commensalis* occurring in this locality shows a narrow range of salinity tolerance. A salinity range between 10 and 20‰ seems to be the most suitable for this species, with the optimum around 17‰. In this grade the polyps are well extended and exhibited active movements and even the liberation of medusae has been noticed. Salinities 25, 30, and 35‰ are apparently unsuitable for the normal activities of this hydroid. Tests conducted during February, when the salinity of the ambient water was around 32‰ showed that the hydroid can tolerate a salinity of even 35‰. During the period of high salinity the hydroid colonies are considerably smaller in size than those noticed during the period of low salinity in the habitat. This relationship between the size and shape of the colony and polyps and the salinity of the ambient water is presented in Table 5. Despite the fact that this hydroid has only a narrow range of salinity tolerance, it seems to have the ability to withstand and exist in the gradually increasing salinity of the post-monsoon and the high salinity of the pre-monsoon through a process of acclimatisation. However, it is apparently incapable of tolerating the rapid fall in salinity on the onset of the heavy rains in June and the very low salinity that prevails during the peak of the monsoon period.

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On the Performance of Otter Trawls Operated from a 15.4 m Trawler off Veraval

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Results obtained with three trawl nets namely, 13.7 m four seam, 15.8 m six seam and 18.3 m four seam operated from a 15.4 m wooden trawler, are presented. Among the three nets operated, 15.8 m six seam trawl and 18.3 four seam trawl were found to be equally effective for the capture of shrimp and during the lean season 15.8 m six seam trawl can be successfully operated to exploit demersal as well as semi-pelagic fish resources. The catch data were analysed using analysis of variance and Gulland's method.

Trawling as a commercial method of fishing has made tremendous strides during the last two decades all along the Indian coast and the present trend is towards acquiring bigger trawlers to cope up with the need to exploit the vast fish resources of Indian territorial waters. Deshpande & Kartha (1964) have described the results of different types of nets operated from a 10.9 m (36′) stern trawler. In the present study, the authors have attempted to assess the suitability of an otter trawl for operation from a 15.4 m wooden stern trawler.

Field trials were conducted in the sea off Veraval and three to nine hauls were taken on each day of operation under identical conditions. The grounds fished were the same as described by Deshpande & Kartha (1964). During the course of the present experimentation, 105 hauls of 70 h total duration were made at depths ranging from 23 to 35 m.

Table 1. *Particulars of gear and accessories*

Head rope m	13.7	15.8	18.3
Foot rope m	15.2	20.5	18.3
Type of trawl	Four seam	Six seam	Four seam
Material	Cotton	Nylon	Cotton
Mesh size cm			
Wing	5.08	6.38	7.62
Belly	5.08	5.08	6.38 to 5.08
Cod end	3.17	3.17	3.17
Length of sweeps m	5 & 10	5 & 10	5 & 10
No. of floats	11	15	13
Extra buoyancy kg	8.7	11.6	10.3
Weight of sinkers kg	11.5	15.7	13.9
Weight of sinkers/m length of foot rope	0.76	0.76	0.76
Tow line	12 mm diameter galvanised flexible steel wire rope		

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Materials and Methods

A wooden fishing vessel OAL 15.4 m fitted with 82/102 HP engine was employed

for the field trials. Three nets, namely, 13.7 four seam (Deshpande *et al.*, 1968) 18.3 m four seam (Joshi & Deshpande, 1964) and 15.8 m six seam (Deshpande *et al.*, 1970) otter trawls were selected for the comparative studies. The otter boards used were similar to the ones described by Satyanarayana & Nair (1962). Particulars of the gear used during the course of the present studies along with accessories are tabulated in Table 1.

Results and Discussion

Based on Table 2, the average catch per trawling hour for 13.7, 15.8 and 18.3 m nets was worked out as 99, 234 and 217 kg respectively which indicates that 15.8 and 18.3 m nets can be successfully operated on commercial basis from a vessel of 15.4 m OAL.

To test the difference of the catching efficiency of the three nets, the quantity caught by each net was converted to logarithmic values, before analysing the variance separately for prawn, fish and total catches. As the difference among the mean catches of the nets is highly significant (Table 3), the nets differ in their performance as judged

Table 2. *Results of fishing operations*

Gear employed	13.7 Four seam trawl	15.8 Six seam trawl	18.3 Four seam trawl
Number of hauls	35	35	35
Duration of hauls	23 h 20 min	23 h 20 min	23 h 20 min
Total catch kg			
Prawn	12.10	31.73	70.90
Fish	2287.90	5424.27	4996.10
Total	2300.00	5456.00	5067.00

Table 3. *Analysis of variance of the logarthmic value of catch*

Source	Sum of squares	df	ms
i) Prawn catch:			
Between nets	1.2545	2	0.6273**
Between days	3.0025	34	0.0883**
Error	2.1345	68	0.0314
Total	6.3915	104	
ii) Fish catch:			
Between nets	3.0349	2	1.5175**
Between days	5.4673	34	0.0883**
Error	1.7357	68	0.0255
Total	10.2380	104	
iii) Total catch:			
Between nets	3.0892	2	1.5446**
Between days	5.3865	34	0.1584**
Error	1.6905	68	0.0249
Total	10.1662	104	

** Highly significant

from the catches. Day to day variation in the catches is also found to be highly significant. The least significant differences (LSD) were calculated to compare the performance of each net with the others. The means of the logarithm of catches and the LSD are given in Table 4.

As evident from Table 4 each net is found to differ from the others in the efficiency for catching prawns and for this purpose 18.3 m net appears to be the most efficient among the three nets considered. For the capture of fish and with regard to the total catch, no significant differences were observed between 15.8 m six seam and 18.3 m four seam trawls and in comparison these two nets were more efficient than 13.7 m net.

The results of the comparison of fish catches between 15.8 m six seam trawl and 13.7 m four seam trawl were also analysed using the method proposed by Gulland (1967) and adopted subsequently by Dickson (1971). For this, the variance,

$$Sx^2 = \frac{1}{n-1}\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right]$$

was first computed and Sx was calculated as 0.207 for the fish catches.

Standard deviation after 35 hauls $\left(\frac{0.207}{\sqrt{35}}\right)$ came to 0.035 and 95% confident limit for the ratio after 35 pairs of hauls

$$= \text{antilog}\ (\text{Log}\ \overset{n}{\Sigma} L/S \pm \frac{2\ Sx}{\sqrt{n}})$$

$$= 2.36\ \text{(ranging from 2.01 to 2.76)}$$

where, L and S are the fish catches of 15.8 m and 13.7 m nets respectively and x = log L/S

This refers to one series of experiments wherein the data on the fish catch ratio of 15.8 m six seam net and 13.7 m four seam net were taken into account and found

Table 4. *The means of the logarithm of catch and LSD*

Type of catch	Mean of the logarithm of catch			LSD
	13.7 m	15.8 m	18.3 m	
Prawn	0.1067	0.2363	0.3774	0.1018
Fish	1.7442	2.1270	2.0778	0.0918
Total	1.7463	2.1297	2.0868	0.0906

Table 5. *Percentage composition of the catch in three nets*

	% composition		
	13.7 m	15.8 m	18.3 m
Prawns	0.52	0.60	1.41
Sciaenids	22.42	27.53	23.07
Polynemids	6.50	2.96	4.66
Eels	1.28	2.43	1.60
Elasmobranchs	12.22	23.45	8.00
Pomfrets	0.23	0.50	0.12
Ribbon fish	0.42	0.52	0.27
Chirocentrus sp.	0.53	0.10	2.14
Pellona sp.	1.95	5.73	3.35
Cat fish	1.53	0.21	0.42
Perches	1.30	0.75	0.68
Miscellaneous	51.10	35.22	56.28

to be 2.36:1 (95% confidence limit 2.01 to 2.76) which proves the effectiveness of the 15.8 m six seam net in the exploitation of fish when compared to 13.7 m four seam net.

During the operation, qualitative as well as quantitative analysis of the catch landed during each haul with reference to each net was done and the data are presented. Prawns, *Polynemids,* eels and miscellaneous varieties of fish were caught more by 18.3 m net. *Sciaenids, Elasmobranchs*, pomfrets, ribbon fish, *Pellona* sp. and perches were landed more by 15.8 m six seam trawl. As most of these fishes are off bottom column swimming fishes, it is inferred that the vertical height obtained by this gear is comparatively higher.

The towing resistance of each net was recorded with the help of a tension meter (Satyanarayana & Nair, 1965) and the average was observed to be 482, 506 and 518 kg respectively for 13.7, 15.8 and 18.3 m trawls. It is concluded that 15.8 m six seam trawl and 18.3 m four seam trawl are best suited for operation from medium sized trawlers along this part of the north-west coast of India.

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Studies on Bridle Lengths in One-Boat Midwater Trawling

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Investigations on the comparative fishing trials to study the effect of bridles for a 10.5 m four equal panelled one-boat midwater trawl are described. Three bridle lengths of 20, 30 and 40 m were tested for relative efficiency evaluation. 30 m bridles are found to be more suitable for the particular design and arbitrary selection of bridle length would be detrimental to the efficiency of nets.

Larsson (1964) while discussing the relative merits and demerits of one-boat and two-boat midwater trawls has opined that the warps in front of the trawl frighten the fish away from the trawl mouth to a certain extent, in the former case. To overcome this he suggested lengthening of the pulling lines between the trawl boards and trawl net. Scharfe (1964) observed insufficient width of the area swept as one of the draw backs in one-boat midwater trawling and as a remedial measure suggested lengthening of the bridles to increase the distance between otter boards, without unduly stretching the net itself side ways. Okenski (1964) while discussing universal one-boat midwater trawl described test results of three lengths for his midwater trawl. Realising the importance of proper lengths of bridles for midwater trawls the present study was undertaken.

The authors (Mhalathkar *et al.*, 1975) in their earlier communication have published results of a new one-boat midwater trawl. The present investigations are aimed to arrive at more effective bridle length for the 10.5 m four equal panelled midwater trawl. Results of comparative fishing efficiency with the three sets of bridles are reported.

Materials and Methods

A tested design of 10.5 m four equal panelled mid water trawl with 120x60 cm vertical curved otter boards described by Mhalathkar *et al.* (1975) was used.

Bridles of 20, 30 and 40 m made of 12 mm dia. polyethylene ropes were employed. The length of the foot rope bridles was slightly longer (0.5 to 1 m) as compared to the head rope bridles and the depressors were attached midway of the foot rope bridles. The rigging of the bridles to the net and otter boards was similar to that described by Mhalathkar *et al.* (1975).

Each day the three selected lengths of bridles were rigged by regular rotation for the same net, otter boards, number of floats on the head rope and the weight of the depressors on foot rope bridles were kept constant for all the fishing operations. 38 comparative hauls were made during the course of 21 days from a 15.4 m vessel with 82/102 H.P. engine. The data on warp tension and horizontal spread were collected in the manner described by Benyami (1959), Deshpande (1960) and Satyanarayana & Nair (1965).

The results of the investigation with three lengths of bridles are given in Table 1, which indicate that 30 m bridles is better suited for the trawl under reference.

For comparing the efficiency of the nets with different bridle lengths, data were collected on catch, horizontal spread and tension on warps offered by each of the rigging pattern, namely, with 20, 30 and 40 m length in a regular rotation. 21 fishing voyages were conducted but for analysis of variance data on catch and tension from 17 voyages and

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Table 1. *Operational data with different lengths of bridles for 10.5 m equal midwater trawl net*

Length of bridles (m) H.R.	20	30	40
F.R.	20.5	31	41
Number of hauls	38	38	38
Depth range m	25 to 40	25 to 40	25 to 40
Warp-depth (scope) ratio	1:4¼	1:5¼	1:5¼
Towing speed knots	2.75	2.75	2.75
Total towing duration h	28	28	28
Average warp tension (on both warps) kg	592.40	561.10	594.90
P. C. horizontal spread (average)	43.26	34.88	32.00
Total catch kg	1838.40	2460.70	1797.25
Catch per hour kg (average)	65.70	87.96	64.20

(H.R.=Head rope; F.R.=Foot rope)

Table 2. *ANOVA for horizontal spread*

Source	ss	df	ms	F
Total	2562.3741	95		
Between bridles	1655.9731	2	827.9865	F=279.72** (2,30)
Between trips	631.9282	15	42.1285	
Interaction (bridles x trips)	88.9508	30	2.9650	
Error	185.5220	48	3.8650	

Critical difference for bridle means =1.2417 m

Average % horizontal opening 20 m bridle =42.06 m

30 m bridle =35.88 m

40 m bridle =31.97 m

Table 3. *ANOVA for catch*

Source	ss	df	ms	F
Total	11.8147	101		
Between bridles	0.3678	2	0.1839	F=2.62 (2,32)
Between trips	6.0848	16	0.3803	
Interaction (bridles x trips)	2.2501	32	0.0703	
Error	3.1120	51	0.0610	

horizontal spread from 16 voyages are only considered. In order to frame the ANOVA table, data on catch are converted to their logarithmic values. Tables 2, 3, 4(a) and 4(b) give the analyses of variance of horizontal spread, catch and tension on port side and starboard side of boat when the net rigged with 20, 30 and 40 m bridle lengths respectively. As the purpose of the investigation was to determine the most effective bridle length which would give higher vertical spread and catch, in all the ANOVA tables prepared, comparisons were made by taking the bridle mean square with interaction (bridles and trips) mean square.

In the case of horizontal spread obtained (Table 2) the ratio of bridle mean square to interaction mean square works out to be F (2,30) = 279.72 which is highly significant

Table 4 (a) *ANOVA for tension on port side*

Source	ss	df	ms	F
Total	34619.85	101		
Between bridles	514.85	2	257.43	F (2,32)=1.40
Between trips	8967.85	16	560.49	
Interaction (bridles x trips)	5870.15	32	183.44	
Error	19267.00	51	377.78	

Table 4 (b) *ANOVA for tension on starboard side*

Source	ss	df	ms
Total	31851.86	101	
Between bridles	0.71	2	0.355
Between trips	6917.02	16	432.31
Interaction (bridles x trips)	7360.63	32	230.02
Error	17573.50	51	344.57

($P<0.01$). The critical difference at 5% level for the bridles works out to be 1.2417 m and the average percentage horizontal spread offered by the three nets with 20, 30, 40 m bridle lengths were 42.06 m, 35.88 and 31.97 m respectively. It could be seen that the 20 m bridle length gave significantly higher horizontal opening most probably at the expense of the vertical opening as compared to 30 and 40 m bridle lengths. Observing the catch landed, definite indications are that the vertical opening which is more advantageous for a midwater trawl, has been increased in the case of 30 and 40 m bridle lengths, but near optimum vertical opening appears to be achieved with 30 m bridle lengths, without adversely affecting the horizontal opening as it must have happened in the case of 40 m bridle length.

As evident from the Tables 1 & 2 the horizontal spread progressively reduced with lengthening of the bridles. This confirms Okenski's observation that the leg length has great influence on the horizontal opening of the net. Further it strengthens Scharfe's view that short bridles transfer the shearing force from the otter boards more efficiently to the net giving better opening width (and may decrease the opening height) which is of disadvantage to this type of trawl.

Hence it is reasonable to assess that there is a corresponding gain in the vertical opening (height) of the net with the decrease in the horizontal opening (width). As these facts plus the present results of the investigations support the views of Parrish (1959) that a large vertical as well as horizontal mouth opening is an essential feature of a midwater trawl.

As regards the catch, though no significant difference could be seen from Table 3 as the F value obtained is falling short of the 5% value. However there is a definite tendency for the value to approach the level of significance as can be seen from Table 1.

Further, in the catch though no significant difference is seen by applying the Anova technique, the actual yield with the 30 m length of bridles is about 33.95% more than with 20 m bridles and 37% more than 40 m bridles, as shown in Table 1.

In the case of the tension on warps no significant difference could be seen as evident from Tables 4 (a) & 4 (b). This fact conclusively indicates that there is no significant difference in the resistance offered by the net with the three different lengths of bridles.

The data on tension on both the warps are shown in Tables 1, 4 (a) & 4 (b) and

the average warp tensions with 20 and 40 m bridles worked out as 592.4 and 594.0 kgs respectively. There is a slight reduction with 30 m bridle length, which is negligible. This is in agreement with the contention of Scharfe (1959) that sweep (bridles) lines account for only 8% of the total resistance of the gear and increase or decrease of their lengths does not influence the total resistance.

From the above discussions it is possible that the same net is capable of landing better catch when rigged with 30 m length of bridles and hence is suitable for this particular design. Further, it also establishes the fact that the length of bridles is one of the main factors governing the shape/contour of the net and thereby the fishing efficiency of the net. The arbitrary lengths of bridles for any given design of net may thus prove to be detrimental to the catching efficiency of the net.

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Development of Lobster Traps—Preliminary Experiments with Three New Designs of Rectangular, Australian Pot and Ink-well Traps

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Results of experimental lobster fishing with three new designs, namely rectangular, Australian pot and ink-well traps at Muttam, Kadiapatnam, Colachal, Enayam and Vizhinjam, south-west coast of India during 1979–80 are reported. Preliminary studies show that Australian pot and rectangular traps as more efficient to the ink-well type.

Trap is a versatile fishing gear used for small and large scale fishing of lobsters (Pease, 1965; Mohan Rajan *et al;* 1981). Traps are selective than lines and trawls. They can be left in the sea during unfavourable weather and can be collected conveniently when favourable weather sets in (Anon, 1980). The traditional Colachal trap used by fishermen of the south-west coast of India (Fig. 6) is described by Miyamoto & Shariff (1961). These traps fabricated out of indigenous bio-degradable material are not compact and not strong enough to withstand rough sea conditions. The life

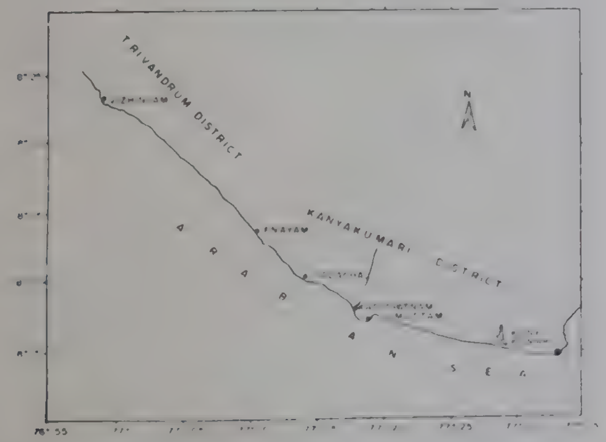

Fig. 1. Centres from where experimental lobster fishing conducted during 1979-80

of these traps seldom exceed three weeks. Being fragile and collapsible, the trap and the catch are often lost in the sea. They are not suitable for mechanisation of fishing. No work appears to have been done in India to improve the traditional lobster traps. The present paper reports the attempts of the authors to introduce new designs with improved materials for the judicious exploitation of the spiny lobster resources of the south-west coast of India.

Material and Methods

Three new designs of rectangular, Australian pot and ink-well type traps were made, considering the shape, size and easiness in handling and operation.

1. *Rectangular trap:* Measures 750 x 500 x 400 mm with a funnel attached to one side. The basal plate consists of four 750 mm long mild steel rods of 10 mm diameter welded to two 550 mm long rods breadth wise. To this, 4 ribs of 400 mm height and 550 mm breadth were attached equidistantly. (Fig. 2). All the traps were of single entry type provided with a 200 mm long funnel with an outside circular opening of 200 mm and internal opening of 120 mm diameters. The rectangular traps were numbered 01, 05, 07, 08, 10 and 11A to facilitate easy identification. WI and WII denotes Colachal traps woven with galvanised iron wire of 14 gauge. All the traps were ballasted to sink to the bottom.

2. *Australian pot:* This semi-cylindrical trap is similar in external appearance to the rock lobster pots used in the east coast of Australia, and hence the name (FAO/UN 1972). Metal traps in this design also measures 750 x 550 x 400 mm. Base of

the trap is similar to that of rectangular type, with 4 mild steel rods of 10 mm diameter and 750 mm length and two rods of 550 mm breadth at two ends. Four bent ribs of 6mm rod fashioned in a semi-circular manner were welded together to this basal plate at equal distance forming the superstructure with a height of 400 mm at the middle. Trap numbers 02, 06, 09, 12 and 17 were in this design (Fig. 3).

3. *Ink-well type:* This hemispherical design is similar in appearance to the Cornish ink-well traps of British coast described by Davis (1958) and Forsyth (1946) and bee-hive pots of Australia (Hughes, 1971). The frame is fabricated in mild steel rod (10 mm) with a circular base of 650 mm and with two strengthening rods inside. Four bent mild steel ribs of 6 mm are attached to the basal ring equidistantly which converge at the top forming the hemispherical superstructure in the form of a dome. Two circular rings of 570 mm and 430 mm diameters are attached parallel to the basal ring connecting the ribs horizontally. The maximum height from the base to the top is 550 mm. The 240 mm long funnel opens from top downwards with an external opening of 200 mm diameter and internal opening of 120 mm diameter, Trap numbers 04 and 15A were of this design (Fig. 4).

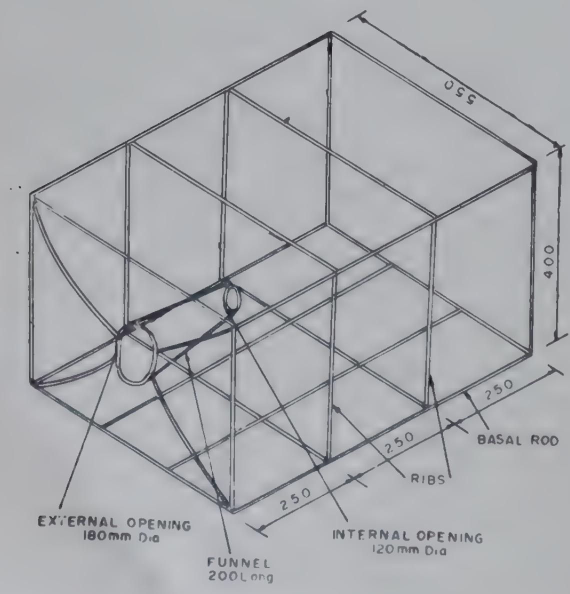

Fig. 2, Design of a rectangular trap (All measurements in mm)

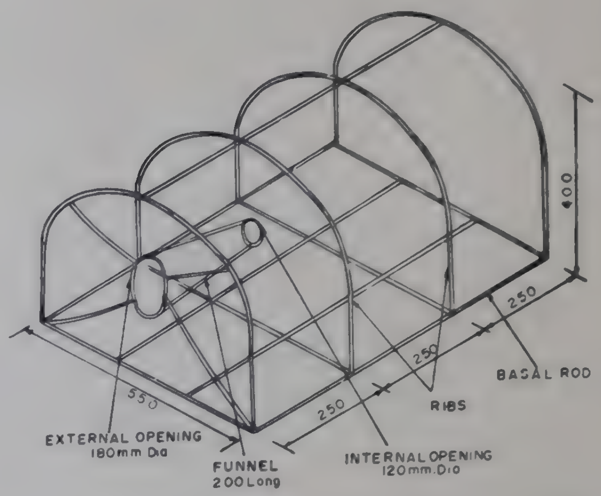

Fig. 3. Design of an Australian pot (All measurements in mm)

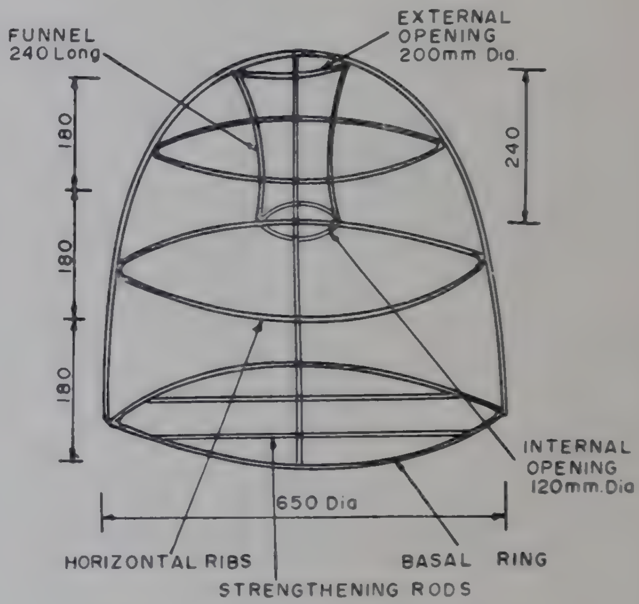

Fig. 4. Design of an ink-well trap (All measurements in mm)

Hemispherical traps with lateral funnel were also used. Such a trap in mild steel rod has a circular base of 600 mm diameter made of 10 mm thick rod. Two strengthening rods of 570 mm in length were welded together within this frame at a distance of 200 mm apart. The superstructure consists of 8 bent longitudinal ribs of (6 mm diameter) 620 mm length, attached to the basal ring equidistantly and welded together at the converging point at the top. The height from the base to the top of the dome is 500 mm. Two horizontal circular rings are attached to the longitudinal ribs, one

below the point of the opening of the funnel and the other above it (Fig. 5). Trap numbers 03 and 14A were of this type.

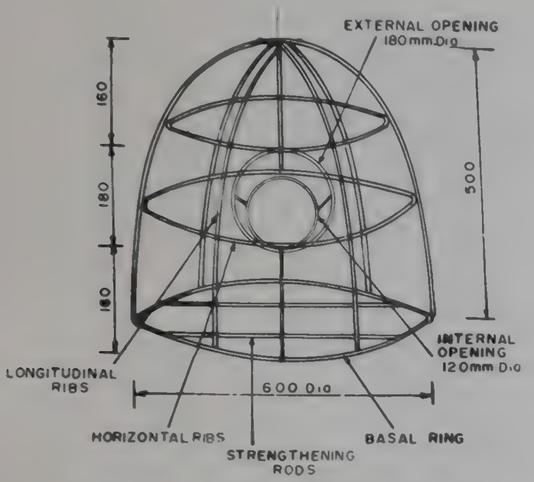

Fig. 5. Hemispherical trap with lateral opening (All measurements in mm)

All the traps were finally covered with secondary protective reinforcements such as chicken wire netting or synthetic net webbing or split bamboo strips. A total of 118 experimental fishing operations were carried out during 1979–80 at Muttam (77° 19′ 24″ E and 8 ° 7′ 24″ N), Kadiapatnam (77° 18′ 30″ E and 8 ° 8′ 12″ N), Enayam (77° 11′ E and 8 °13′ N), Colachal (77° 15′E and 8 ° 11′ N) and Vizhinjam (76 ° 59 ′ E and 8 ° 22′ N) in the south-west coast of India (Fig. 1) with a Colachal trap as control. The position of traps was rotated providing equal chances for all the traps to be tried from every point of setting. This was not strictly adhered to under adverse field conditions as well as in grounds where the lobster population was homogeneous.

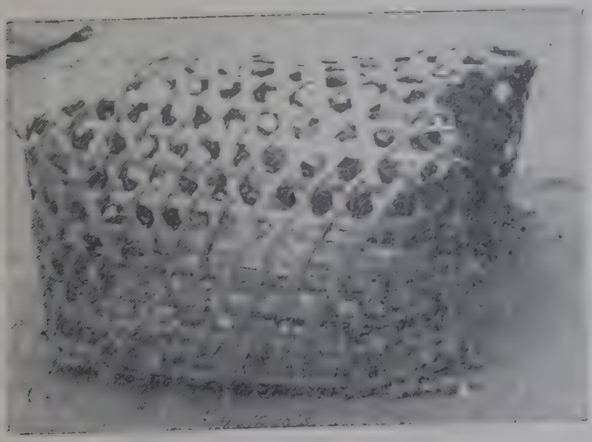

Fig. 6 Indigenous Colachal trap

The traps were laid and retrieved with the help of local fishermen by skin diving. The fishing grounds were located at 0.5 to 3 km from the shore at depths 8 to 15 m. Four-logged boat catamarans were used to reach the ground and back. On reaching the ground traps were baited with 50–100 green mussels *(Perna* sp*)*. Baited traps were thrown into water and by diving, the traps were set in position. Traps were hauled up after 24 h.

To select the better traps with which further experiments are to be carried out for confirmation of the findings, catch data was compared separately for each centre and also pooling all the centres. To reduce the difference in catches caused by difference in availability, the consecutive experimental days which gave better catches (Cochran & Cox, 1957) were taken for comparison. Within these days the simultaneously operated traps were compared on the basis of mean catch (Table 1).

Results and Discussions

In the design of traps, behaviour of the lobsters to the gear is of paramount importance. Spiny lobsters are sedentary, dull-witted, easily scared gregarious organisms and are lured into the traps by suitable baits. Bennet (1974) has pointed out that the catch of a baited trap is the result of a sequence of complex and variable events, the physical characteristics of the trap being decisive only at the end of the sequence. It begins with the initial awareness of the animal that attractive chemicals are present in the water (Mackie, 1973) and ends up with the entry, consumption of bait and attempt to escape, thereafter.

In the case of the rectangular and Australian pots it was noticed that the effects of storm buffetings and underwater currents are considerably reduced as the centre of equilibrium is lower than in the hemispherical one. Rectangular traps are considered to stack better. Newman & Pollock (1969), considers rectangular traps much superior to hoop nets because they continue to catch lobsters inspite of inclement weather. In

Table 1. *The average number, average weight and average length of lobsters caught in traps operated simultaneously at various centres*

	Enayam							Kadiapatnam						Colachal				
Trap nos.	02	04	05	08	WI	14A	C	05	08	09	WI	WII	C	02	06	11A	17	C
Average number of lobsters estimated for 100 days of operation	38	—	35	58	54	—	46	3	46	—	29	36	46	29	38	—	—	9
Average wt. of lobsters caught per day g	93	—	93	189	148	—	141	10	111	—	100	102	119	65	98	—	—	34
Average length of lobsters caught for the entire season mm	134	—	145.6	161.3	157.2	—	155.8	170	146.2	—	187.5	160	162.5	136.7	153.8	—	—	180

	Muttam													Vizhinjam				
Trap nos.	01	02	03	04	05	07	08	09	10	11A	14A	15A	C	01	03	06	WII	C
Average number of lobsters estimated for 100 days of operation	15	20	—	—	—	15	10	—	—	—	—	—	40	11	—	28	44	61
Average wt. of lobsters caught per day g	31	47	—	—	—	43	31	—	—	—	—	—	134	21	—	63	118	221
Average length of lobsters caught for the entire season mm	143.3	150	—	—	—	190	175	—	—	—	—	—	202.9	130	—	134	147.5	170

ink-well traps, as the funnel is located at the top middle portion, it makes the opening equidistant from any direction of entry. The broad circular base inparts greater bottom stability. In Australian pots, the streamlined design makes it more rugged and easy to repair. With minimum welding and limited projecting corners, this trap is convenient to handle. In addition, being elongated and with the centre of equilibrium lower, storm buffeting under the sea was found less. Catchwise also Australian pots were better compared to ink-well types. One drawback noticed in the newly designed traps was the shape and the position of mouth opening. As both the openings were in the same plane situated close to the floor of the trap, they did not function as valves at all in preventing the escape of lobsters. Majority of the lobsters escaped after feeding, as evidenced by the empty shells of the bait left in the trap.

The estimated average number of lobsters caught per 100 operations, average weight of lobsters caught per operation and the average length of lobsters are presented in Table 1. The average number of lobsters is estimated for 100 operations only to avoid fractions in the number of lobsters. On the basis of the average number of lobsters caught, traps 06 at Vizhijam, 02, 05, 08 at Enayam, 02, 06 at Colachal, 05, 08 at Kadiapatnam (Table 1) and 02 at Muttam gave better catches (Table 1). For the catch obtained in the same part of the season, the number of days operated, average number, average weight and average length of lobsters caught in traps 02, 05, 06 and 08 are presented in Table 2. The average catch shows that traps 02, 06 and 08 as promising. Thus for the traps 02, 05, 06 and 08, the combined analysis and the centrewise analysis are in good agreement (Tables 1 and 2). For establishing the comparative efficiency of these traps, further experiments are necessary. To ascertain whether there is any wide difference in the size of lobsters, the average weight of lobsters was calculated (Tables 1 & 2). The average weight was found to increase with average numbers and it appears that there is no wide difference in the size of lobsters from trap to trap. Tables 1 & 2 show that the average length of lobsters caught in trap 02 is relatively smaller than that caught in other traps.

Table 2. *The average number, average weight and average length of lobsters caught in the same part of the season in the promising traps*

Traps nos.	02	05	06	08
No. of days operated	33	35	20	37
Average no. of lobsters caught per 100 days operation	48	17	40	68
Average wt. of lobsters caught per day g	115	45	103	193
Average length of lobsters caught for the entire season mm	138	148	146.2	155.7

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The Bacteriology of Oil Sardine *(Sardinella longiceps)* and Mackerel *(Rastrelliger kanagurta)* caught from Tropical Waters off Cochin. I - Quantitative Aspects*

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The total aerobic viable plate counts (TPCs) of skin, gills and intestine of newly caught oil sardine *(Sardinella longiceps)* and Indian mackerel *(Rastrelliger kanagurta)* at four different temperatures, namely $36 \pm 1°C$, $28 \pm 2°C$ (RT), $8 \pm 1°C$ and $1 \pm 1°C$, are reported. The total plate count at RT of the skin of oil sardine and Indian mackerel were in the range of 10^3 to 10^7 and 10^4 to 10^6 per cm^2, that of gills in the range of 10^5 to 10^8 and 10^4 to 10^8 per g and that intestine in the range of 10^5 to 10^9 and 10^5 to 10^8 per g respectively. The TPCs were markedly affected by the incubation temperature. Incubation at $28 \pm 2°C$ gave the highest count; at $36 \pm 1°C$ and $8 \pm 1°C$, the counts decreased by nearly 1–2 log. cycles from that at RT. Incubation at $1 \pm 1°C$ registered the lowest count. The peak values for bacterial counts of these fishes occurred at different periods of the year.

Considerable amount of information is available on the quantitative and qualitative aspects of bacterial flora of fish from the Northern sea (Stewart, 1932; Liston, 1956; 1957 and Georgala, 1958), the North Atlantic (Reed & Spencer, 1929, Gibbons, 1934 and Dyer, 1947), and the Pacific (Liston & Colwell, 1963). Data regarding the fishes in tropical seas are rather limited. Wood (1940, 1950 and 1953) had studied the number and types of bacteria found in the marine fish caught in the warmer waters of Australia. In India, Venkataraman & Sreenivasan (1952, 1954) and Karthiayani & Iyer (1967, 1971) investigated the bacteriology of the fish caught in the waters off east and west coast of India. Though Karthiayani & Iyer (1971) made a detailed investigation on the bacterial flora of oil sardine caught off Cochin, their observations were limited to the mesophilic bacteria only. The present study was designed to systematically investigate all aspects of the bacterial population, both mesophiles and psychrophiles of the tropical fishes caught off Cochin, from the Arabian sea, with special reference to the seasonal changes.

*Part of Ph.D. Thesis (of the first author) approved by the University of Kerala, Trivandrum

Materials and Methods

Oil sardine and mackerel immediately after capture were transferred aseptically into wide mouthed sterile glass bottles and brought to the laboratory, keeping the bottles under ice (within 2–4 hours after catch).

Both nutrient agar (NA) and sea water agar (SWA) were used to determine the total aerobic viable plate count (TPC). Nutrient agar was a distilled water based medium prepared as per Salle (1954). Sea water agar consisted of 10 g bactopeptone (w/v), a trace of ferric phosphate, and 15 g agar powder (Difco), dissolved in one litre aged sea water, the pH being 7.2, sterilized at 1.05 kg per cm^2 for 15 min.

Four to five fish were used for determination of bacterial count. For bacterial count of the skin, a fixed area on each side of the fish was aseptically swabed and the swab was well agitated with 10 ml of sterile aged sea water or sterile saline (0.85% NaCl in distilled water). Proper serial dilutions from this were pour-plated or spread-plated using SWA and NA.

For bacterial count of gills, 2–3 g of the gill tissue was aseptically cut and homogenised with 100 ml sterile sea water and

appropriate dilutions were used for plating either by pour plate or spread plate technique using SWA and NA. For bacterial count of intestines, 1–2 g of the gut with contents were aseptically removed from 4–5 fish and were homogenised with 100 ml sterile sea water. Appropriate dilutions were plated with SWA and NA. The plates were incubated at $1\pm1°C$ for 21, $8\pm1°C$ for 10, $28\pm2°C$ (RT) for 3 and $36\pm1°C$ for 3 days. After incubation, counts were taken using a Qubec colony counter, equipped with a guide-plate ruled in square centimetres. Counts falling between 30 and 300 at the particular temperature of incubation were used for calculation of TPC. Colonies on crowded plates and on plates with spreading colonies were estimated by the method of APHA (1962).

Results and Discussion

1. *Total bacterial count*

The total aerobic plate counts (TPC) of the skin, gills and intestines (with contents) of newly caught sardine and mackerel at four different temperatures on two different plating media are given in Tables 1 and 2.

The TPC per sq. cm of skin of oil sardine, on SWA ranged between 2.15×10^3 and 2.50×10^7 and that of Indian mackerel between 4.63×10^4 and 8.35×10^6 at room temperature (RT, $28\pm2°$ C). The TPC/g of gills at RT were in the range of 2.42×10^5 to 8.76×10^8 and 6.81×10^4 to 3.14×10^8 in the case of oil sardine and Indian mackerel respectively. The counts/g at RT of intestine with contents of oil sardine and Indian mackerel respectively were in the range of 7.12×10^5 to 5.34×10^9 and 3.51×10^5 to 9.86×10^8.

These data show that the bacterial density is the highest in the intestine and the lowest on the skin, that of the gills being intermediate in the case of both the fishes. This observation is in agreement with the results of Liston (1956), who had recorded a total bacterial count of 10^3 to 10^6 per sq.cm of skin and 10^3 to 10^7 per gram of the guts of flat fish from North Sea. Similar results were also obtained by Shewan (1962) andGeorgala (1958) in North Sea cod.

The effect of incubation temperature on the plate count is very significant as observed from the Tables 1 and 2. Change in the incubation temperature either to the higher side or to the lower side from RT resulted in a decrease in the counts of skin, gills and intestines of both oil sardines and mackerel. The decrease by 1 to 2 log cycles in the TPCs at $36\pm1°$ C compared with those at RT, implies that a significant portion of the bacteria recovered at RT is not mesophilic. Similarly, incubation at $8\pm1°$ C caused a decrease of 1 to 2 log. cycles from the count at RT, indicating that lower temperature eliminated at least a portion of the mesophiles that are recovered at RT. Incubation at still lower temperature resulted in very considerable lowering of count. The bacterial counts at $1\pm1°$ C were only 0.02 to 2.2% and 0.08 to 0.28% of the TPC at RT in the case of the skin of oil sardine and mackerel respectively. The corresponding counts of gills were only 0.06 to 0.29% and 0.10 to 0.32% of the counts at RT and of intestines only 0.001 to 0.02% and 0.0006 to 0.03% of the counts at RT. This indicates that only a very small proportion of the bacteria of fish caught from tropical waters is capable of growth at $1\pm1°$ C. This observation is different from that of Liston (1956) who reported that although the counts obtained by incubation at 0°C was lower than that obtained at 20°C, such difference was not excessively great in the case of fish caught from North Sea. In the case of fish from northern waters, where the temperatures of water in which fish are caught range from –2° to +12° C, the viable counts at 37°C was only 5% of the counts at 0°C and 20°C, which were approximately equal (Shewan, 1949; Georgala, 1957 b, 1958). Whereas, in tropical waters off India, the temperature of sea water ranges from 20°C to 32°C and naturally one should expect the observed phenomena in the bacterial count of the fish caught from those waters. The results of Karthiayani & Iyer (1967 and 1971) on the bacterial count of oil sardine, caught off Cochin, at RT and 8°C compared well with this observation. However, they have not studied the TPCs at 1°C and $36\pm1°C$.

Tables 1 and 2 also present data on the recovery of bacteria from oil sardine and mackerel, on distilled waterbased medium

Table 1. *Total bacterial count (TPC) of newly caught oil sardine at different temperatures of incubation*

Sample	Bacterial count on SWA				Bacterial count on NA			
	Temperature of incubation				Temperature of incubation			
	28±2°C	36±1°C	8±1°C	1±1°C	28±2°C	36±1°C	8±1°C	1±1°C
Skin (per cm²)	2.15×10^3 to 2.50×10^7	7.68×10^3 to 8.14×10^5	6.24×10^2 to 9.21×10^5	48 to 6818	2.14×10^2 to 7.71×10^5	1.78×10^2 to 3.42×10^4	1.21×10^2 to 8.63×10^4	11 to 864
Gills (per g)	2.42×10^5 to 8.76×10^8	1.47×10^3 to 6.91×10^5	8.18×10^3 to 5.07×10^4	7.12×10^2 to 5.07×10^4	6.46×10^3 to 5.93×10^6	1.88×10^1 to 9.21×10^3	2.2×10^2 to 2.32×10^5	1.12×10^2 to 6.78×10^2
Intestine with contents (per g)	7.12×10^5 to 5.34×10^9	1.17×10^3 to 4.35×10^7	2.35×10^3 to 4.35×10^7	2.07×10^2 to 5.34×10^4	9.28×10^2 to 8.42×10^4	1.09×10^2 to 2.28×10^4	2.42×10^2 to 7.99×10^4	Nil to 9.21×10^2

Table 2. *Total bacterial count (TPC) of newly caught Indian mackerel at different temperatures of incubation*

	Bacterial count on SWA				Bacterial count on NA			
	Temperature of incubation				Temperature of incubation			
	28±2°C	36±1°C	8±1°C	1±1°C	28±1°C	36±2°C	8±1°C	1±1°C
Skin (per cm²)	4.63×10^4 to 8.35×10^6	8.22×10^3 to 5.37×10^5	8.28×10^3 to 2.02×10^5	128 to 7137	6.28×10^2 to 5.38×10^4	1.91×10^2 to 6.21×10^4	3.02×10^2 to 1.19×10^4	92 to 4064
Gills (per g)	6.81×10^4 to 3.14×10^9	2.47×10^3 to 3.47×10^5	1.13×10^3 to 3.28×10^6	2.17×10^2 to 32.7×10^4	3.03×10^3 to 9.28×10^6	2.49×10^2 to 4.54×10^4	1.09×10^2 to 6.93×10^4	1.21×10^1 to 4.73×10^2
Intestines with contents (per g)	3.51×10^5 to 9.86×10^8	2.11×10^4 to 6.04×10^7	9.21×10^3 to 6.44×10^6	1.07×10^2 to 6.27×10^4	7.20×10^3 to 822×10^6	6.72×10^2 to 6.74×10^5	3.21×10^2 to 8.62×10^4	3.07×10^1 to 9.04×10^3

(NA). The counts of skin, gills and intestine, at all the four temperatures namely, 36±1°, 28±2°, 8±1° and 1 ± 1° were lower from the corresponding count on SWA. This decrease was of the order of 1 to 2 log cycles in the case of skin, 2 log cycles in the case of gills and 3 to 5 log cycles in the case of intestines. The decrease in count implies that the majority of the bacteria associated with marine fish required higher salt content in the media. The more pronounced decrease in the count of intestines, indicated the true marine nature of the bacteria of the intestines, in that they seem to be nutritionally exacting regarding the requirement of sea water for growth.

Karthiayani & Iyer (1967) have recorded similar observations on the recovery of skin and gut bacteria of oil sardine on SWA and distilled water agar (DWA). They reported that in 50% of platings, there was no growth in the DWA at RT in the case of gut bacteria, though there was growth in SWA.

As regards the total bacterial count, the results reported here (Tables 1 and 2) show comparatively higher values in the case of the TPCs of skin, gills and intestines of both oil sardine and Indian mackerel. The corresponding bacterial load of fish from temperate water is lower. The bacterial counts of North Sea fish were 10^2–10^5/cm^2 of skin, 10^3–10^7/g of gills and 10^3–10^8/g of gut contents (Shewan, 1962). In the case of Japanese flat fish, Simudu *et al.* (1969) have reported a bacterial count of 10^4/cm^2 of skin, 10^3–10^5/g of gills and 10^3–10^7/g of intestine. Karthiayani & Iyer (1967), in the case of the oil sardine caught from tropical waters, have obtained 10^3–10^7 organisms/g of skin with muscle and 10^4–10^8/g of guts. Hence, the bacterial loads in the fishes from tropical and sub-tropical waters, are higher than the bacterial population of the fishes from colder waters. According to Shewan (1977) the flora of fish appears to be a function of the environment. "The somewhat higher loads on marine fish from tropical and subtropical areas appear to confirm Kriss" finding (1971) of greater numbers in waters from hotter areas than in the colder regions" (Shewan, 1977).

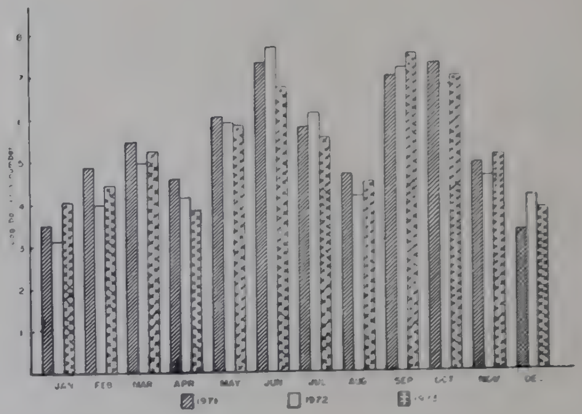

Fig. 1. Seasonal variation in the bacterial count on the skin of newly caught oil sardine at 28±2° C on SWA

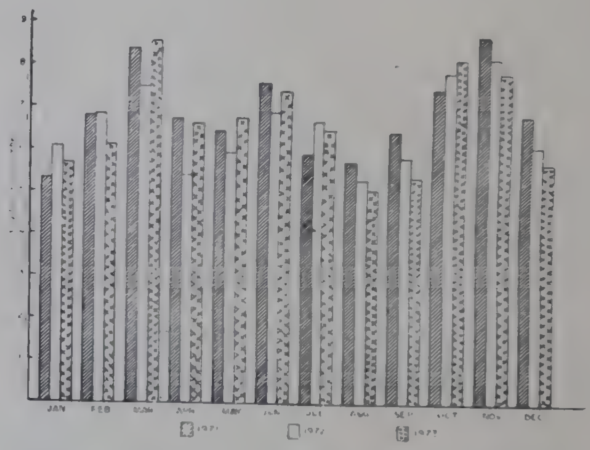

Fig. 2. Seasonal variation in the bacterial count of the gills of newly caught oil sardine at 28±2°C on SWA

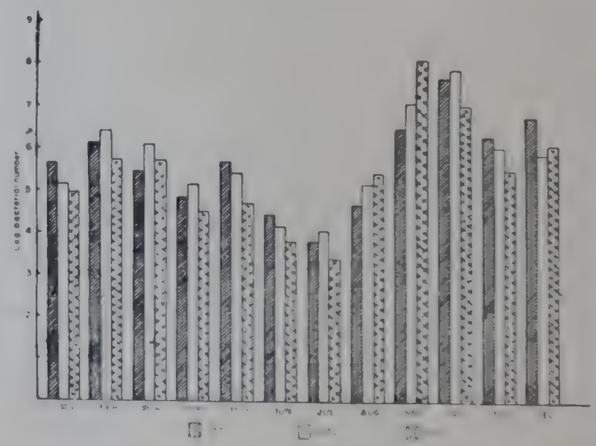

Fig. 3. Seasonal variation in the bacterial count of intestines (with contents) of newly caught oil sardine at 28±2°C on SWA

2. *Seasonal variations in the bacterial counts*

Figures 1 to 3 show the seasonal variations in the bacterial counts at 28±2° C (RT) of the skin, gills and intestine (with contents) of oil sardine. Similarly, figures 4 to 6 represent the seasonal variations in the bacterial counts at RT of the skin, gills and intestine (with contents) of Indian mackerel.

Figures 7 to 9 and 10 to 12 show the seasonal variations in the TPCs at 8±1° C, of skin, gills and investines with contents of oil sardine and Indian mackerel respectively.

In the case of oil sardine, the highest bacterial loads on skin, at 28±2° C are obtained in June and September–October period; while peak values in the total plate counts of gills are obtained in March and October–November season. For intestines with contents, the highest bacterial counts are registered in September–October season.

At 8±1° C, peak values in the TPCs of skin of oil sardine are recorded in June to October season. In the case of gills, peaks are obtained in February–March, June and October–November seasons. For intestine with contents, highest counts are registered in May and October–November periods.

At RT, only one peak each is obtained in the case of the bacterial count of skin and gills of Indian mackerel, that is in January–February season. But, for intestines, highest bacterial counts are recorded in October and March–April period.

At 8±1°C, the peak values for the bacterial counts of skin of Indian mackerel are obtained in January, whereas for gills, significantly higher values are not found, eventhough during December–January–February period, small peaks are obtained. But in the case of intestines with contents, two peaks are registered, one in November–December period and the other in March–April season.

A comparison of the figures 1 to 3 with figures 7 to 9 shows that in the case of oil sardine, the peak values for the total bacterial counts of skin, gills and intestines, at both 28±2°C (RT) and 8±°C, almost correspond to the same period of the year. Similarly, a comparison of figures 4 to 6 and 10 to 12 shows the peak values in the case of skin, gills and intestines of Indian mackerel at RT and 8±1°C, in more or less the same seasons of the year.

A full comparison of the data on oil sardine and Indian mackerel is not possible, because the fishery of Indian mackerel is limited to a period of nine months from September to the following May, while oil sardine is available throughout the year. However, it can be observed from a comparison of figures 1 to 3 with 4 to 6 and 7 to 9 with 10 to 12 respectively, that, eventhough caught from the same waters, the peak values for bacterial counts for oil sardine and mackerel, occur at different periods of the year. Thus, while the highest bacterial counts of skin of oil sardine are obtained in June and September–October season, the corresponding peaks for mackerel is in January–February period. Similarly, for the gills of oil sardine, peak counts are obtained in March and October–November period, while the peak values for the gills of mackerel are registered in January–February season. So also, in the case of intestines, oil sardine recorded the highest counts in February–March and September–December seasons and Indian mackerel registered peak values in November and March–April period.

According to Shewan (1961) the seasonal variations in the bacterial load on fishes, are a reflection of similar variations in the environment. Thus, in sole, skate (Liston, 1955, 1956) and cod (Georgala, 1957 a, 1958) caught off Aberdeen, two peak loads (at 0°C and 20° C) occurred during the year, in the late spring and autumn, each following at least 1 to 3 months interval after the spring and autumn plankton outbursts.

Peak bacterial loads are also said to coincide with maximum water temperature (Shewan, 1961). The higher counts at 28±2°C, recorded in the warmer months of March in the case of gills and May–June in the case of skin of oil sardine and March–April in the case of intestines of Indian

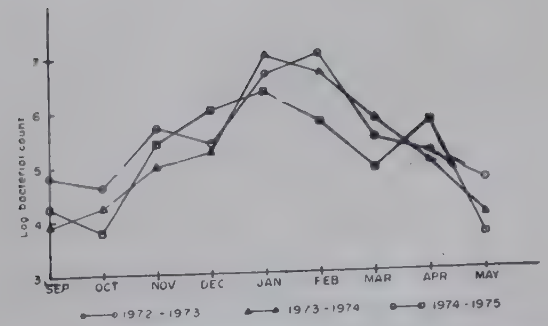

Fig. 4. Seasonal variation in the bacterial count on the skin of newly caught Indian mackerel at 28±2° C on SWA

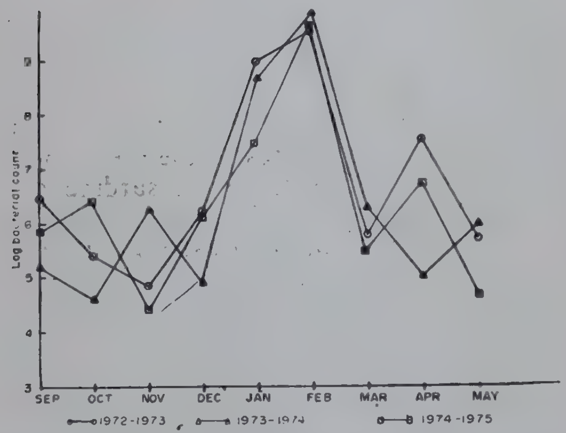

Fig. 5. Seasonal variation in the bacterial count of gills of newly caught Indian mackerel at 28±2° C on SWA

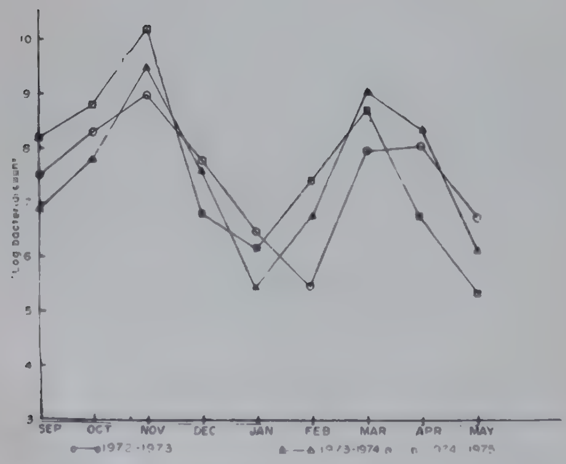

Fig. 6. Seasonal variation in the bacterial count of intestines (with contents) of newly caught Indian mackerel at 28±2° C on SWA

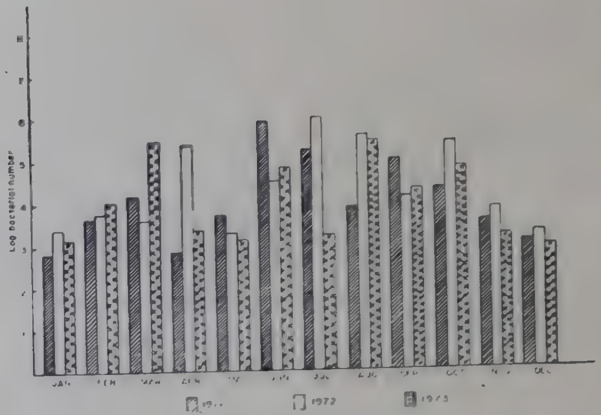

Fig. 7. Seasonal variation in the bacterial count on the skin of newly caught oil sardine at 8±1°C on SWA

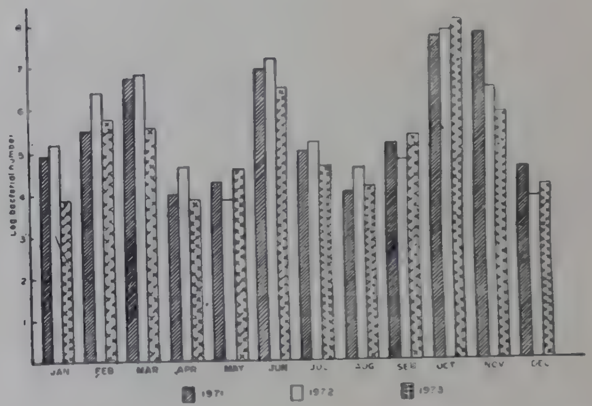

Fig. 8. Seasonal variation in the bacterial count of gills of newly caught oil sardine at 8±1°C on SWA

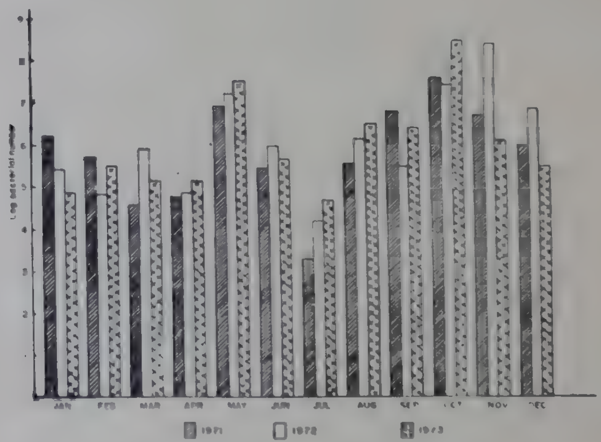

Fig. 9. Seasonal variation in the bacterial count of intestines (with contents) of newly caught oil sardine at 8±1°C on SWA

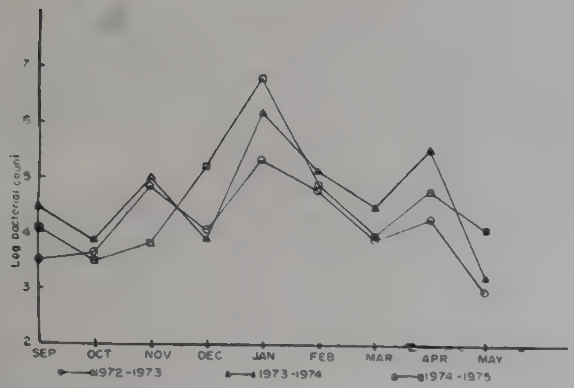

Fig. 10. Seasonal variation in the bacterial count on the skin of newly caught Indian mackerel at 8±1°C on SWA

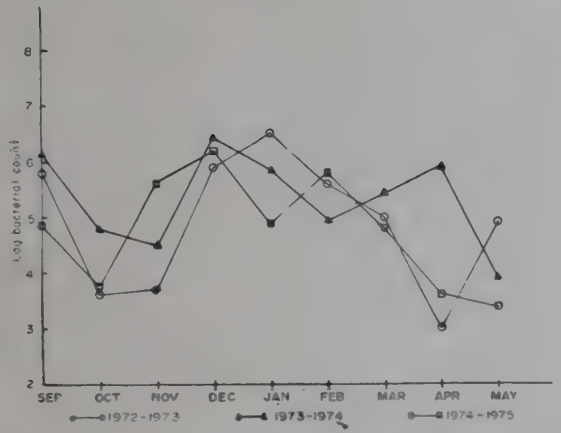

Fig. 11. Seasonal variation in the bacterial count of gills of newly caught Indian mackerel at 8±1°C on SWA

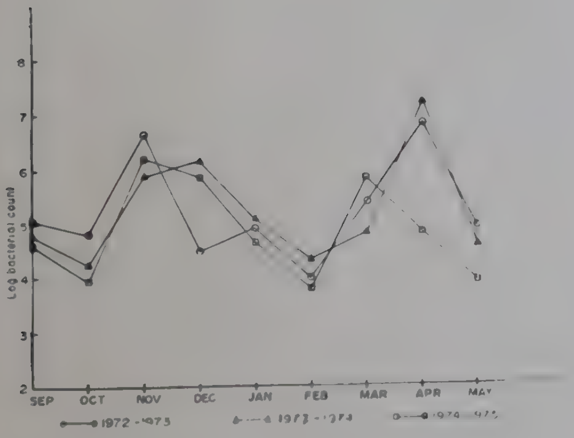

Fig. 12. Seasonal variation in the bacterial count of intestines (with contents) of newly caught Indian mackerel at 8±1°C on SWA

mackerel may be explained like this. Similarly, the lower counts obtained in December–January season in the case of intestine of mackerel may be attributed to the lower water temperature during winter. Such observations have been made by Georgala (1957 a, 1958) in the case of North Sea cod. Also Karthiayani & Iyer (1971) have reported peak values in the bacterial counts at 37°C of the skin with muscle, gills and intestines of oil sardines in the warmer months.

As explained earlier, though caught from the same waters, the peak counts of oil sardine and mackerel are obtained during different periods of the year. This cannot be explained on the basis of the changes in the environmental temperature alone, but a number of other factors-physical, chemical and biological–might influence the flora. The species of the fish might also affect the bacterial load (Shewan, 1961). Liston's observations (1955, 1956) that bacterial populations particularly of gills of sole and skate caught from the same area in the same time, were different, support this view. The micro-environments, say the constitution of the slime, for example, present in the particular fish might affect their bacterial load.

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Fish. Technol. (1982) **19**, 97-100

Squilla Protein: Chemical Composition and Nutritive Value

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Protein extract prepared from squilla *(Orato squilla nepa)*, a commercially unexploited crustacean, was analysed for crude protein and essential amino acids. All the essential amino acids except tryptophan and threonine were present in nutritionally adequate amounts. The protein was evaluated for its nutritional quality in respect of growth rate, protein efficiency ratio (PER) and liver nitrogen content by feeding on rats. Growth rates and protein efficiency ratios were similar in rats fed on casein, squilla protein and a combination of squilla protein and casein (1:1) diet. The weight of liver and kidneys were normal.

Squilla is a crustacean caught in large quantities along with shrimp during trawling operations. A correct estimate of the total catch of squilla by fishing trawlers along the east and west coasts of India cannot be made since most of it is thrown overboard when caught and whatever landed mixed with fish and prawns is again disposed off as waste at the landing sites. It has not been put to any commercial use so far. Attempts have been made to prepare quality chitosan from squilla by Madhavan & Nair (1975) and by Moorjani *et al.* (1977). A simple method for the preparation of protein from squilla has been reported by Garg *et al.* (1977). The objectives of the present study were to develop useful products from squilla and to determine the chemical composition of the squilla protein as well as evaluate its nutritional quality by the PER assay.

Materials and Methods

Of the three important commercial varieties of squilla namely, *Orato squilla nepa, Orato squilla holoschista* and *Harpio squilla naphida,* the first named species was used in the studies. Squilla caught was iced immediately and brought to the laboratory within 6 to 8 h of catch. It was processed either immediately or after storage in ice for 1–2 days. The details of the method developed to produce protein from squilla have been reported earlier (Garg, *et al.,* 1977). Fine grade lactic casein from a commercial source was used for the preparation of the control diet.

Standard analytical procedures of AOAC (1975) were followed for the analyses of moisture, nitrogen, fat and ash in the squilla protein extract. Available lysine was determined by the modified method of Carpenter (Booth, 1971). The amino acid composition of the sample was determined microbiologically according to the method of Shockman (1963). Chemical score was calculated using the amino acid scoring pattern proposed by FAO/WHO (1973).

Protein efficiency ratio (PER) of squilla protein was measured in rats at 4 weeks by the method of Chapman *et al.* (1959). The effects of feeding squilla protein to albino rats, such as growth rate, PER, kidney and liver weight were studied.

Three different experimental diet was formulated. The composition of the diet is given in Table 1. Casein was chosen as the standard reference protein and the amount of protein was kept at 10% level in all the diet. Adequate quantities of mineral mixture (Hubbell *et al.,* 1937) and vitamins (Chapman *et al.,* 1959) were also added. Since all the diet had the same composition with the exception of the protein part, the difference between the three diet will only be that due to the differences in the

Table 1. *Percentage composition of the diet*

Ingredients	Casein	Squilla protein	Casein and squilla protein (1:1)
Casein	12.6	—	6.3
Squilla protein	—	15.2	7.6
Refined groundnut oil	5.0	5.0	5.0
Shark liver oil	2.0	2.0	2.0
Vitamin mixture	1.0	1.0	1.0
Salt mixture	1.0	2.0	2.0
Dextrose	25.0	25.0	25.0
Corn starch	52.4	49.8	51.1

Table 2. *Chemical composition of squilla protein*

	%	Range %
Moisture	5.3	4.4– 6.4
Protein (N x 6.25)	65.5	64.6–68.5
Ash	13.6	12.3–14.0
Ether extract	7.9	5.8–10.3
Available lysine (g/16 g N)	5.4	

amino acid profile of the proteins used in the 3 groups.

Ten male weaning rats (Wistar Strain, inbred) were assigned to each test diet. The animals were divided at random into groups adjusted to give similar mean weights and were housed individually in cages having wire mesh bottoms. The initial weight of the animals was 47–55 g. They were fed on weighed amount of the diet and water was supplied *ad libitum*. During a period of 28 days, the daily food intake and weekly increase in body weight were recorded. The protein efficiency ratio was calculated as g weight gain/g of protein consumed. At the end of the experiment, the animals were killed, liver and kidneys weighed after removing the connective tissues. Total nitrogen of liver was also determined.

Results and Discussion

The chemical analyses of six different batches of squilla protein are given in Table 2. It may be seen that the material contains a high percentage of protein and moderate levels of ash and fat.

The essential amino acid pattern of squilla protein in comparison with that of casein (Milner *et al.*, 1978) and the FAO/WHO reference protein is presented in Table 3. It can be seen that the most significant differences between the two types of proteins are the tryptophan and threonine levels. Compared to the provisional pattern set by FAO/WHO (FAO/WHO, 1973) lysine, isoleucine and phenylanine plus tyrosine are excessive, leucine, valine and the sulphur containing amino acids adequate and threonine and tryptophan the limiting amino acids, the amino acid score being equal to 80%. The lysine content of squilla protein is much higher than that contained in the pattern and is almost equal to that of casein. Of this 76% is biologically available as measured by the modified method of Carpenter (Booth, 1971).

Growth rates of rats fed with the 3 diet are shown in Fig. 1. Diet containing squilla protein induced growth rates similar to casein and no stunting effect was noticed.

Feeding trials showed that the three groups of rats consumed the formulated diet in good quantities. There was no rejection by the rats for the feeds containing squilla protein and no unhealthy symptoms were observed in the two groups fed on diets containing squilla protein throughout the experimental period. There was no significant difference in intake, digestibility or PER when fed on casein, squilla protein or a mixture of the two,

Table 3. *Essential amino acid pattern of squilla protein to casein and FAO/WHO amino acid scoring pattern*

Amino acid	Squilla protein (g per 16 g nitrogen)	Casein (g per 16 g nitrogen)	FAO/WHO pattern (g per 16 g nitrogen)
Isoleucine	5.2	16.7	4.0
Leucine	7.0		7.0
Lysine	7.1	8.2	5.5
Methionine – Cystine	3.6	3.7	3.5
Phenylalanine – tryosine	7.3	10.7	6.0
Threonine	3.2	4.5	4.0
Tryptophan	0.8	1.4	4.0
Valine	5.0	6.4	5.0
Total	39.2	52.6	36.0

Table 4. *Protein efficiency ratio of djfferent diet*

Assay group	Average weight start g	Average weight gain g	Average food intake g	Average protein consumed g	PER
Casein	55	65	223	22.3	2.92
Squilla protein	47	58	205	20.5	2.83
Casein & squilla protein (1:1)	49	66	231	23.1	2.86

Table 5. *Relative weight of liver and kidney and liver nitrogen of rats fed with the experimental diet*

	Total liver wt g	Kidney wt per 10 g body wt g	Liver nitrogen mg/total liver
Casein	5.74	0.84	184.5
Squilla protein	5.66	0.90	190.6
Casein & squilla protein (1:1)	5.60	0.85	181.6

although casein had a slightly higher PER value (Table 4). When casein and squilla protein were mixed in equal quantities, an increase was recorded in PER value. However this difference was not significant. The slightly lower PER values can be attributed to the low food intake by rats in the initial stages and the limiting quantities of certain essential amino acids.

The relative weights of liver and kidneys and total liver nitrogen levels of the animals fed on the three diets are presented in Table 5. The organs selected had weights similar to controls and the nitrogen levels in the liver were also similar. No negative effect was noticed.

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Soluble Protein Isolates from Low Cost Fish and Fish Wastes

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The method of preparation, composition, amino acid content, protein efficiency ratio and areas of possible application of water soluble protein isolates from low cost fish and fish wastes are discussed in detail in this communication.

One of the most widely spread nutritional deficiencies in the world today is that of high quality protein. A large proportion of India's population subsist on cereal grains, the proteins of which are low in quantity as well as in quality. Protein malnutrition is, therefore, an important cause of infant mortality, stunted physical growth, low work output, premature ageing and reduced life span.

A major portion of the marine fish catch in India (1.06 lakh tonnes per annum) is constituted by low cost fish of several species obtained as by-catch from shrimp trawlers (Anon, 1979). Besides this a good percentage of quality fish goes as waste during processing. Determination of the proximate composition of several species of Indian miscellaneous fish has shown that their protein content varies from 16.0 to 20.8 g per 100 g of whole minced wet fish (Kutty Ayyappan *et al.*, 1976). Wastes from filleting and canning of quality fishes contain 12.4 to 13.6% crude protein.

Protein hydrolysates in various forms are presently used in therapeutics as a source of readily assimilable protein in gastro-intestinal and liver disorders and in the treatment of severe cases of protein malnutrition (Elman, 1947; Trowell *et al.*, 1954; Bose & Guha, 1961). Starting materials for such hydrolysates are usually liver, meat, fish, casein, vegetable proteins etc. For the past few decades several workers (Sen, *et al.*, 1962; Tarky *et al.*, 1973; Yanez, *et al.*, 1976) have attempted to develop methods for conversion of low cost fish and fishery wastes into acceptable and highly nutritious soluble preparations. Methods of preparation, composition, nutritive value and probable areas of use of protein isolates from fish and fishery wastes are presented in this paper.

Materials and Methods

Fresh fish were collected from fishing boats and were used either immediately or frozen whole and stored at –23°C for future use. Papain was used as the proteolytic agent. Hydrolysis of the comminuted fish flesh was carried out by the method of Thankamma *et al.* (1979). Moisture, ash, protein and fat were determined as per AOAC (1975). Amino acid distribution of the hydrolysates was determined microbiologically by the method of Shockman (1963) and biological evaluations were performed on albino rats as growth experiments according to the method of Chapman *et al.* (1959). The diet contained 10% protein and casein was used as the reference standard. Supplementation of the hydrolysate was done by admixture with the limiting amino acid at 0.1% level or casein (1:1).

Results and Discussion

The yield of protein hydrolysate from trash fish and fish waste are given in Table 1. The products were usually golden yellow to brown hygroscopic powders and could be stored in screw-capped glass or polythene bottles with proper wax coating. The shelf-life of the products from threadfin bream, jew fish and lizard fish and cat fish waste were studied for 6 to 12 months. The solubility and colour of the products remained unaffected.

Table 1. *Yield of protein hydrolysate from low cost fish and fish waste*

Substrate	Yield (%) Dry solubles/Wet fish of fish waste
Lizard fish *(Saurida tumbil)*	13.3
Jew fish *(Johnius* sp.)	10.6
Threadfin bream *(Nemipterus japonicus)*	12.0
Cat fish *(Tachysurus* sp.)	10.9
Cat fish waste	4.0
Perch *(Nemipterus bleekeri)*	7.5
Milk fish *(Chanos chanos)* waste	8.1
Jew fish waste	7.8

Table 2. *Composition and properties of protein hydrolysates*

	Lizard fish whole	Threadfin bream whole	Milk fish waste
Moisture (%)	5.0	3.5	1.6
Protein (%)	83.1	86.4	93.1
Fat (%)	0.1	0.1	Nil
Ash (%)	5.4	7.6	5.2
Colour	Pale brown	Reddish brown	Creamy yellow
Solubility	Instantly and completely soluble in water		

Proximate composition and other properties of few hydrolysates are presented in Table 2. The protein content of the isolates was about 90% on dry weight basis and fat content was negligible. Usually the samples were rich in lysine and showed excellent amino acid profiles. Amino acid pattern of a typical hydrolysate from threadfin bream is presented in Table 3. Chemical score was calculated using the amino acid scoring pattern proposed by FAO/WHO (1973). The limiting amino acids were tryptophan and threonine and the chemical score was 80.

Table 3. *Essential amino acid profile of hydrolysate from threadfin bream*

Essential amino acid	Amino acid (g/100 g protein) FAO provisional pattern	Protein isolate
Isoleucine	4.0	5.6
Leucine	7.0	7.6
Lysine	5.5	9.4
Methionine + Cystine	3.5	5.0
Phenylalanine + Tyrosine	6.0	6.4
Threonine	4.0	3.9
Tryptophan	1.0	0.8
Valine	5.0	5.2

The results of nutritional evaluation of the hydrolysate as such and after supplementation are shown in Table 4. The rats showed slight diarrhoea when fed on diet with hydrolysate alone. The food intake was low and the protein efficiency ratio was inferior to that of casein. However, supplementation of the hydrolysate with the limiting amino acids at 0.1% level or admixture with casein brought about a significant change in nutritive value and gave PER values almost equivalent to that of casein.

Table 4. *Nutritional evaluation of hydrolysates from threadfin bream**

	PER
Casein	2.8
Hydrolysate	1.8
Hydrolysate supplemented for limiting amino acid	2.4
Hydrolysate + Casein (1:1)	2.7

*Protein at 10% level

Areas of fortification

Methods of preparation and results on consumer acceptability studies on high energy food incorporating fish hydrolysates have been reported (Gopakumar, 1973; Prabhu *et al.* 1975; Gopakumar *et al;* 1975). Protein content of commercial cereals, the staple food in developing countries, is between 6.2 to 13.6 g per 100 g of edible portion of foods (Gopalan *et al.,* 1980). Amino acid profiles of cereal grain proteins often deviate from the needs of man and animals, lysine being the first limiting amino acid for most of them (Block & Mitchell, 1946). The fish hydrolysate is high in lysine (Table 2) and may be used for incorporation in cereal and other foods.

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Autobrinometer

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An instrument developed for the rapid and accurate measurement of brine concentrations during blanching without disturbing the routine blanching operation is described. The concentration is sensed by a platinum electrode conductivity cell and displayed in a moving coil meter after conversion of the electrical signals into D. C. voltage. The instrument can measure in the range 5 to 12% with an accuracy of $\pm 1\%$. The errors caused mostly are those due to wide temperature variations of the brine between 95 to 102°C and the unknown quantities of protein.

Blanching is one of the most important steps in canning of prawns to bring down the moisture of the product to the required level, to coagulate proteins and to provide proper texture, shape and characteristic pink colour to the meat. Chief factors controlling the drained weight in canned prawns are concentration of brine and the duration of blanching. Usually the same blanching liquor is used for repeated blanchings each time making up the concentration to the original level manually through guess work. Certain factories use hydrometers for rough estimations of the concentration by density measurements.

There are no rapid methods or devices available for continuous monitoring of the concentration of blanching liquid. The usual method of salt estimation by analytical method is time consuming. A suitable device for direct and continuous measurement of salt content of blanching solutions designed and developed by the authors is reported.

Methods

Principle

The important method of finding the resistance of an electrolyte in which no polarisation effects are produced is Kohlransch's method which makes use of a Wheatstone bridge arrangement. Instead of D.C. source, an A.C. source of sinusoidal alternating current was employed for energising the network eliminating polarisation effect on the cell. The frequency of the alternating current needed for the same was produced from an oscillator.

If X = resistance of the column of length L of the liquid,
A = area of cross section,
P = specific resistance of the liquid,

$$X = P \times \frac{L}{A}$$

$$\text{Specific conductivity } K = \frac{1}{P}$$

If an electrolytic solution contains c gram equivalents per litre and if the specific resistance of the solution be P, conductivity K of the solution is $\frac{1}{P}$

$$\text{Equivalent conductivity} = \frac{\text{conductivity}}{\text{concentration}} = \frac{K}{C}$$

When concentration increases conductivity decreases and for dilute solutions of many electrolytes the specific conductivity is almost exactly proportional to the concentration, namely, $K \propto C$. In general the conductivity of an electrolyte increases with rise of temperature also.

Instrument

The instrument (Fig. 6) consists of a sensor and an electronic display meter. Sivadas (1981) has used a platinum electrode sensor for finding the salinity of sea water. The sensor is a glass tube 15 cm length and 10mm diameter, wherein two platinum electrodes are embeded inside, 5 cm apart. The whole tube containing the electrodes is

enclosed inside a PVC tube, filling the inter space with araldite for making it rugged and insulated (Fig. 1). The instrument was fabricated out of indigenous components.

Electronics

The electronic circuit consists of an oscillator, a bridge circuit, an operational ampli-

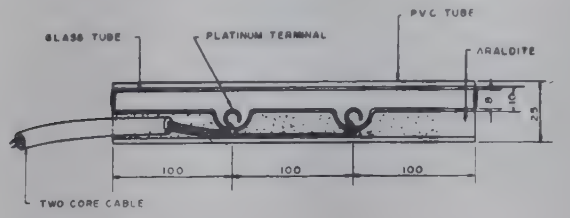

Fig. 1. The cross section of the conductivity cell

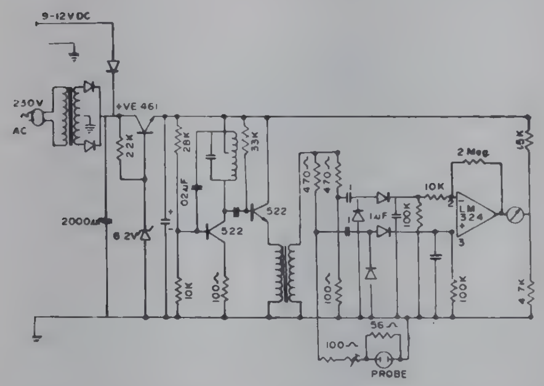

Fig. 2. The electronic circuit used in this instrument

fier and a display meter as given in Fig. 2. The oscillator produces sinusoidal waves at 1000 Hz. These oscillations are buffer amplified and given to a Wheatstone bridge net work. The sensor forms one of the four arms of the bridge. The bridge output will be the modulated signals with carrier from the oscillator and the intelligence from the transducer. The two outputs of the bridge are separately detected and filtered to produce steady D.C. proportional to the signals. These are fed to the two inputs of an operational amplifier working in differential mode to eliminate errors due to ambient temperature changes, slight change of the power supply and frequency instability of the oscillator. The output of the operational amplifier gives the information in D.C. voltage between 0 to 5. The D.C. voltage is converted to the required information in engineering units by proper potential division.

Calibration

The meter was calibrated by comparing the meter reading for known salt concentration in the range 5 to 12% containing 0.2% citric acid at 98 $\pm 2^{\circ}$ C with the values obtained by chemical analysis of these solutions, taking into consideration the conductivity errors caused by the dissolved proteins leaching from prawns into the blanching liquor. The effect of dissolved proteins on the electrical conductivity measurements was studied by Rao (1974). It was found that this error was proportionally less at

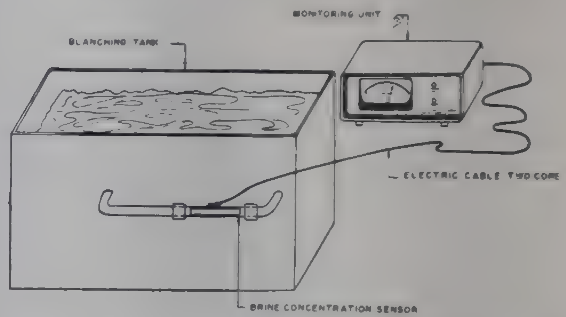

Fig. 3. The installation of the sensor outside the blanching tank

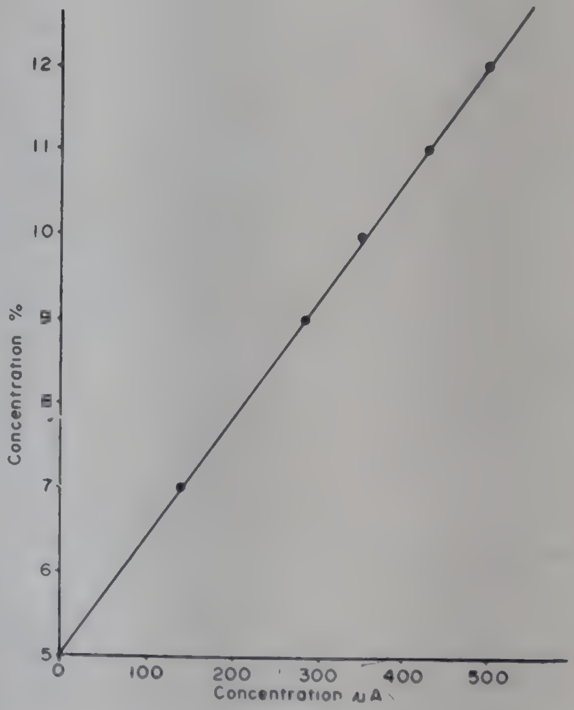

Fig. 4. The relation between estimated concentration of brine and concentration indicated by the meter

elevated temperatures and fairly constant irrespective of protein concentration due to repeated blanchings. The error in the meter reading due to protein content and temperature of the blanching solution was estimated to be about 1%.

Results and Discussion

The relation between brine concentration and meter reading was studied and it was found to be fairly linear. The linearity was obtained by shunting the probe by a very low resistance (Fig. 4). The effect of temperature over conductivity was studied for the temperatures from 95 to 102° C and the error due to this was estimated to be about 1% (Fig. 5).

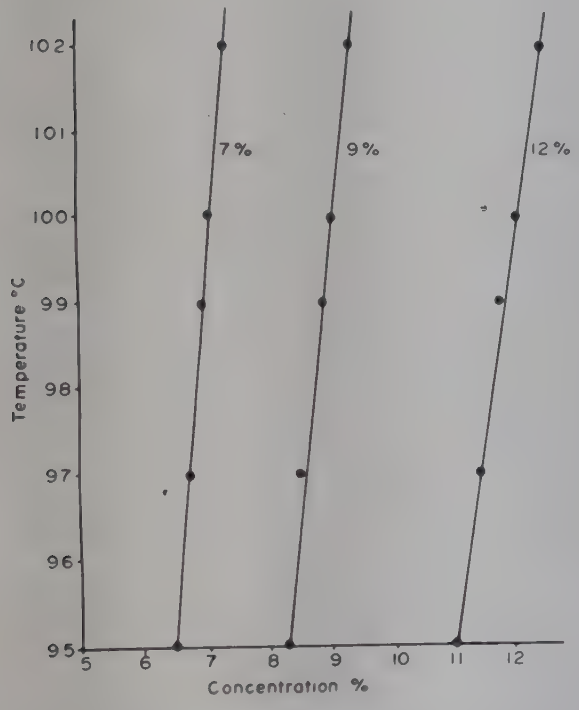

Fig. 5. The variation of concentration with temperature from 95°C to 102°C

The sensor made of platinum electrodes and fused to glass can withstand very high temperatures. The interspace between the glass tube and PVC tube is filled fully with araldite which could withstand the temperature of blanching solution. The sensor can be mounted permanently outside the blanching tank with inlets and outlets connected for salt solution to circulate through the transducer tube (Fig. 3). The transducer can also be mounted temporarily inside the blanching tank as and when the measurements are to be taken.

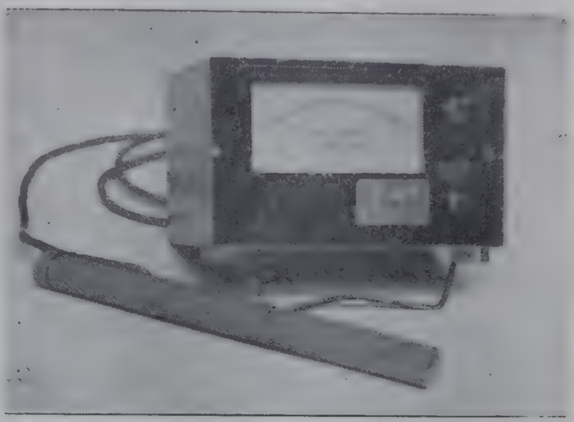

Fig. 6. The photograph of the instrument with its sensor

The following are main features of this instrument:-

Range	:	5–12% (other ranges are possible)
Accuracy	:	±1%
Power supply	:	9 VD. C./230 VA.C.
Power consumption	:	30 mA at 9V
Approximate cost	:	Rs. 4,000/-

The authors are grateful to the Scientists, Processing Division of Central Institute of Fisheries Technology for useful suggestions and help in the calibration of the instrument and to Dr. C. C. Panduranga Rao, Director for encouragement and permission to publish the paper.

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Freezer Temperature Monitor and Alarm

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An electronic instrument for measuring freezer temperature in the range of +40 to -40°C is described. The salient features of the instrument are, remote display, (digital and analogue versions with an accuracy of ±0.1 and ±0.5°C respectively), and provision for continuous record of temperature. Two types of sensors using thermistor and P. N. junction of transistor were used for temperature sensing.

Measurement and control of temperature of freezers and cold storages are of great importance for maintaining the quality of the stored products. Variation of storage temperature of frozen fish adversely affect various properties of fish. Different types of instruments have already been developed using many physical as well as electrical properties of substances. For example in platinum resistance thermometers, change in resistance of a piece of platinum wire with temperature is made use of. Generation of thermo e.m. f. between the junctions of two dissimilar metals is employed in measurement of temperature using thermocouples. Difference in co-efficient of thermal expansion of two different metals is made use of in the thermostatic control of temperature. Change in resistance of a semiconductor with respect to temperature is employed in the measurement of temperature using thermistors. Large signal output for a given range of temperature can be achieved using thermistor sensors. Rao (1968) and Sivadas (1978) have described the use of thermistors for temperature measurements. The forward voltage drop across the base-emitter junction of a transistor varies linearly with temperature and this method has also been employed for measurement of temperature (O' Neil & Derrington, 1979). Recently the National Semiconductors have developed an integrated circuit which includes a temperature sensor, a stable voltage reference and an operational amplifier all housed in a single chip (Scott, 1980). The present report deals with an electronic thermometer developed to measure and control temperature in freezers and cold storages with specific advantage of remote measurement and alarm.

Methods

The freezer temperature monitor and alarm consists of two types of sensors, namely thermistor and P. N. Junction and the associated electronic circuits displaying temperature in digital or analogue meters. The alarm electronics give alarm as the temperature deviates away from the preset levels.

Thermistor probe and associated electronics

Thermistor having a resistance of 1 kilo ohm at 25°C is made use of as the sensor. This is encased properly by a metallic tubing

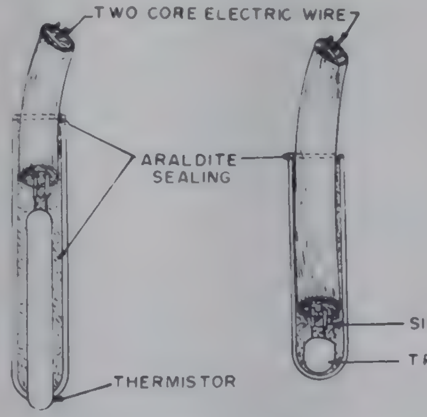

Fig. 1. Cross section of thermistor and P. N. junction probes

as shown in Fig. 1 Variation of resistance of thermistor is given by

$$R = R_o \exp. \left[B \left(\frac{1}{T} - \frac{1}{T_o} \right) \right] \quad - \quad (1)$$

Where R_o = Resistance at reference temperature T_o (°K)

R = Resistance at T (°K)

B = material parameter describing the slope of resistance vs. temperature.

The temperature co-efficient of resistance can be calculated from (1) as

$$a = \frac{1}{R}\frac{dR}{dt} = -\frac{B}{T^2} \qquad (2)$$

The non-linearity in temperature resistance characteristics of the thermistor is overcome by shunting with proper value of standard resistance as shown in Fig. 2. In the case of the thermistor sensor used, a resistance of 3.3 K ohm. is used as the shunt, in order to get a linear characteristic within the measuring range of 40° to —40°C. This

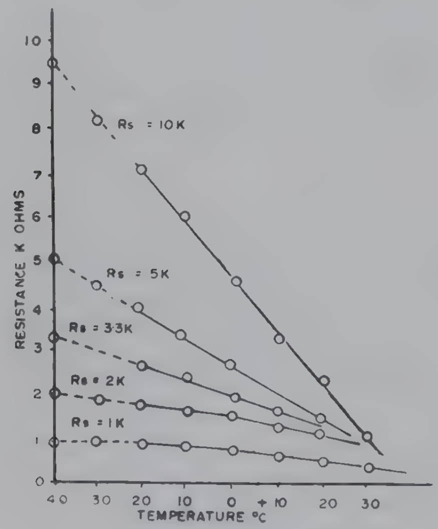

Fig. 2. Linearisation of thermistor with shunt resistance Rs.

is achieved by sacrificing the sensitivity to some extent. Thermistor probe is connected in the circuit as one of the arms of a wheatstone bridge as shown in Fig. 3. The bridge gets unbalanced due to the variation of resistance of the thermistor depending on the temperature of freezer or cold storage. Output voltage of the bridge is amplified by an operational amplifier and fed to a 0 to 100 micro ammeter as shown in the Fig. 3.

In the digital version of the instrument the amplifier output is connected to a potential divider arrangement and a 3½ digit LED display is connected across this point and a

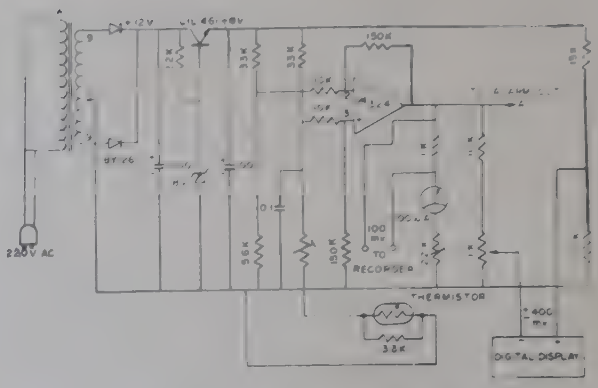

Fig. 3. Electronic circuit of the instrument using thermistor probe

fixed reference voltage as shown in the figure. Resistances of this network are chosen in such a way that a potential difference of +400 mV and —400 mV exists across the LED display at 40° and —40°C respectively.

P. N. junction probe and associated electronics

Base emitter junction voltage of a NPN silicon transistor is found to vary linearly with temperature. Variation of junction voltage is in the order of– 2 mV per degree centigrade in the temperature range of —40° to 40° C and this transistor junction is used as the temperature sensor. The probe is made by enclosing the transistor inside a stainless steel tube as shown in Fig. 1 and connected in the circuit as shown in Fig. 4. Voltage across the probe varies with variation of temperature of the freezer or cold storage. This voltage variation is amplified by an operational amplifier and fed to a 0 to 100 micro ammeter with proper series resistance. Sufficient bias voltage is given to the amplifier so that the out put voltage reaches the required level corresponding to the temperature range of 40° to —40° C. In digital version of the instrument, the output of the amplifier is connected to a 3½ digit LED display.

Alarm control circuit

This has got two differential amplifiers ICa and ICb as shown in Fig. 5. Voltage at point A varies with the temperature to be measured. As long as the temperature remains within the preset limits there is

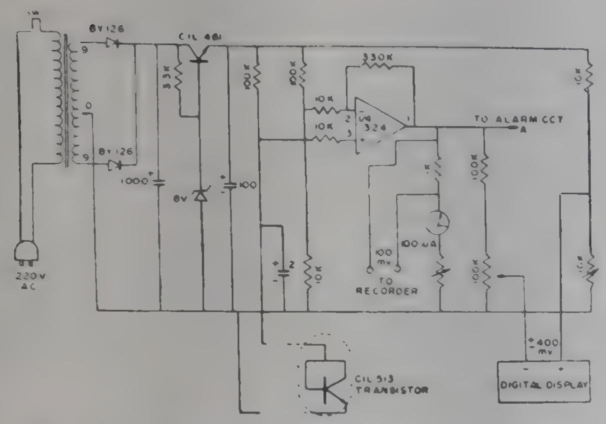

Fig. 4. Electronic circuit of the instrument using P. N. junction probe

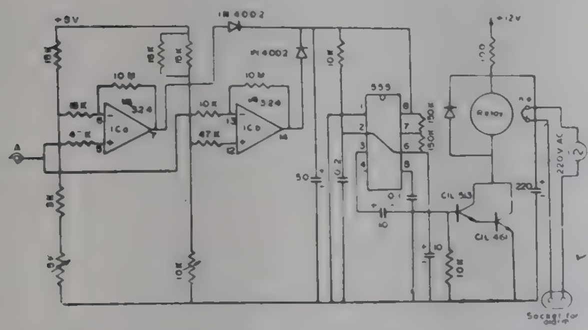

Fig. 5. Electronic circuit operating the alarm

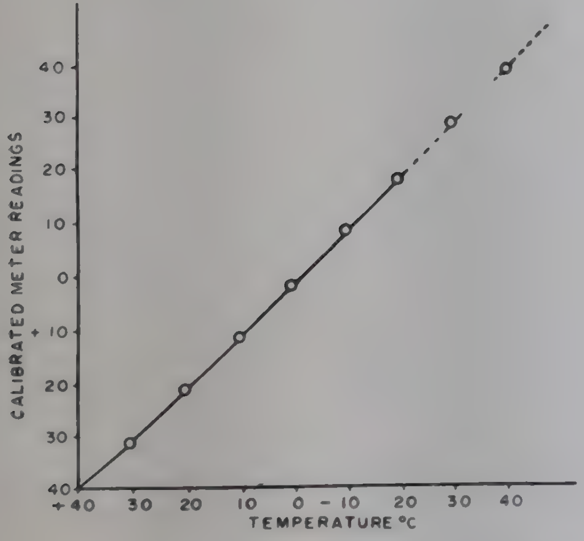

Fig. 6. Calibration curve of the instrument with thermistor probe

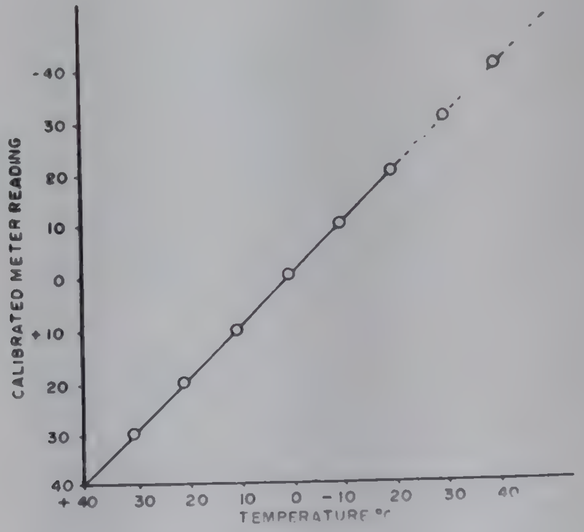

Fig. 7. Calibration curve of the instrument with P. N. junction probe

no output from any of these amplifiers. But once the temperature crosses the limit, an output voltage is produced by either one of the amplifiers. This voltage is used to operate the associated circuit which drives a 6V relay. An alarm operating at 230 V. AC is connected to the relay. The upper and lower temperature points at which the alarm has to be operated is set by adjusting the reference voltage to the amplifiers with the help of corresponding alarm set potentiometers.

Calibration

Calibration of the instrument was done by keeping the probe in different constant temperature baths and noting the corresponding meter readings. Temperature in the negative range upto —20°C was obtained from the deep freezer. Hence the curves after —20° C are extrapolated considering the theoretical linearity in the case of P. N. junction probe and nature of curves in the case of thermistor probe.

Results and Discussion

Calibration curves of the instrument with thermistor and P. N. junction probes are shown in Figs. 6 and 7 respectively. In the case of P. N. junction, output signals came linearly proportional to temperature. But in thermistor, some nonlinearity is observed which is found to increase with wider range of temperature scale. An accuracy of ± 0.1°C is obtained in the instrument with P. N. junction probe. In thermistor version the accuracy is reduced

to ±0.5°C due to the nonlinear characteristics though it has got a resolution of 0.1°C with digital display.

The P. N. junction probe has got a very high response time compared to the thermistor probe. Response time of thermistor probe in the temperature range from 30° to 0°C is nearly 20 sec and that of P. N. junction probe is nearly 2.5 min. Since temperature of freezers and cold storages do not fluctuate very fast, the above high response time is quite acceptable and both types of probes can be used in them for temperature measurements.

Remote display of temperature is an advantage of the instrument over the conventional thermometers fitted in freezers and cold storages, where temperature can be observed only at close distance ranges from the instrument. In the case of thermistor probe a distance of even kilometers between the sensor and display unit is possible because of the high resistance of the thermistor compared to the resistance of the connecting wire. The instrument works at 9 V DC supplied by built in power supply operating from 230 V AC with a current consumption of 40 mA in analogue version and 100 mA in the digital LED version.

The authors are grateful to the Scientists, Engineering and Processing Divisions, Central Institute of Fisheries Technology, Cochin-682 029 for useful suggestions and help in the calibration of the instrument. The authors are thankful to Dr. C. C. Panduranga Rao, Director for encouragement and permission to publish the paper.

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Preliminary Account on the Intensity of Fouling in Karwar Waters

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Biology of fouling in Karwar waters is presented. The composition of fouling communities, their fluctuations in relation to hydrographical factors such as temperature, dissolved oxygen, salinity and the influence of the nature and texture of the substratum on fouling communities are discussed.

In recent years, considerable attention is being paid towards the study of fouling organisms which attach on to all kinds of structures in saline waters causing serious problems to the submerged timber structures, piles, pillars, buoys and the hulls of watercrafts. While information is available on the fouling organisms of the other Indian regions, (Palekar & Bal, 1957; Ganapathy *et al.*, 1958; Antony Raja, 1959; Nair, 1965, 1967; Nair, 1967 b; Menon & Nair, 1971; Menon *et. al.*, 1970). Virtually nothing is known on this important group from the Karwar waters.

It is in this context, an attempt has been made to study the composition of the fouling organisms of Karwar, their distribution and differential seasonal abundance.

Karwar bay (14° 48′–51′N and 74° 06′E) (Fig. 1) is an outpush of Arabian sea with Kali river emptying into it on the northern side. During the south-west monsoon period which begins in early June, the bay waters get diluted with rain water and estuarine discharge, decreasing the salinity and temperature but increasing the turbidity. Based on the influence of the monsoon, the year can be distinguished into three well-defined periods, the pre-monsoon (Feb–May), monsoon (June–Sept.) and the post-monsoon period (Oct.–Jan).

The two stations selected (Kodibag and Baithkol) were 5 km from each other and represent two different ecological habitats. Kodibag is situated at the Kali river mouth and Baithkol, is located to the south of the bay taking an incurve from the inshore waters (Fig. 1). Owing to the intense operation of fishing vessels, this locality is subjected to pollution with lube oil and organic matter. The depth vary from 5–8 m and 6–8 m for stations 1 and 2 respectively in between the tidal shifts.

Fig. 1. Karwar bay showing test sites Kodibag (A) and Baithkol (B)

Material and Methods

Racks (60 x 30 cm) with fixed glass panels (15 x 10 cm) were suspended in the water at a depth of 4 m at both the stations. Fortnightly data were collected for seven months from March to September 1979, from smooth and rough glass panels immersed vertically. The observations and analyses of the physico-chemical parameters were performed by standard methods (Salinity–Mohr Knudsen method, Oxygen-Winkler method, Temperature–Thermometry and vertical extinction co-efficient by S. D. reading/0.95).

Table 1. *Settlement of fouling organisms in Kodibag (Station 1)*

		Balanus				Oysters				Polychaetes				Bryozoans			
		A		B		A		B		A		B		A		B	
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
March	1.	61	51.69	61	51.69	2	1.69	2	1.69	45	38.14	45	38.14	10	8.47	10	8.47
	2.	63	62.94	65	51.57	1	0.99	4	3.18	30	29.97	46	36.51	9	8.99	11	8.71
April	1.	63	46.67	63	46.67	3	2.22	3	2.22	62	45.82	62	45.82	7	5.19	7	5.19
	2.	58	44.62	67	45.27	3	2.31	6	4.05	61	46.92	65	43.91	8	6.16	10	6.76
May	1.	45	48.91	45	48.91	1	0.00	0	0.00	40	43.48	40	43.48	7	7.61	7	7.61
	2.	41	44.57	46	46.47	1	1.09	3	3.03	41	44.57	41	41.42	9	9.78	9	9.97
June	1.	40	72.56	40	72.56	0	0.00	0	0.00	9	16.36	9	16.36	6	10.91	6	10.9
	2.	38	76.00	48	74.99	2	4.00	0	0.00	7	14.00	7	10.93	3	6.00	9	14.06
July	1.	41	93.17	41	93.17	0	0.00	0	0.00	3	6.83	3	6.83	0	0.00	0	0.00
	2.	36	100.00	28	87.50	0	0.00	0	0.00	0	0.00	4	12.50	0	0.00	0	0.00
August	1.	1280	99.77	1280	99.97	1	0.11	1	0.11	2	0.22	2	0.22		0.00	0	0.00
	2.	1664	99.84	1320	99.63	0	0.00	1	0.05	1	0.08	2	0.16	1	0.08	2	0.16
September	1.	1250	99.97	1250	99.97	1	0.11	1	0.11	0	0.00	0	0.00	2	0.22	2	0.22
	2.	1300	99.93	1340	99.63	0	0.00	1	0.07	0	0.00	0	0.00	1	0.07	4	0.30

A = Short term panel; B = Long term panel; a = Frequency of occurrence; b = Relative frequency of occurrence (%); I = Ist fortnight; 2 = IInd fortnight

Table 2. *Settlement of fouling organisms in Baithkol (Station 2)*

		Balanus				Oysters				Polychaetes				Bryozoans			
		A		B		A		B		A		B		A		B	
		a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
March	1.	107	86.30	107	86.30	11	7.05	11	7.05	2	1.28	2	1.28	4	2.56	4	2.56
	2.	158	90.82	141	84.94	9	5.17	12	7.23	1	0.58	3	1.81	6	3.45	10	6.0
April	1.	120	85.11	120	85.11	3	2.13	3	2.13	17	12.06	17	12.06	1	0.71	1	0.71
	2.	60	76.93	125	80.13	2	2.56	5	3.21	16	20.51	24	15.38	0	0.00	2	1.28
May	1.	15	42.85	15	42.85	8	22.85	8	22.85	4	11.43	4	11.43	8	22.85	8	22.85
	2.	16	59.26	18	40.00	6	22.22	10	22.22	2	7.41	6	13.34	3	11.11	11	24.44
June	1.	14	77.76	14	77.16	3	16.66	3	16.66	0	0.00	0	0.00	1	5.56	1	5.56
	2.	12	93.32	15	65.35	1	21.78	5	21.78	0	0.00	0	0.00	0	0.00		13.04
July	1.	40	97.57	40	97.57	1	2.43	1	2.43	0	0.00	0	0.00	0	0.00	0	0.00
	2.	60	95.23	65	97.01	1	1.99	2	2.99	0	0.00	0	0.00	2	2.78	0	0.00
August	1.	118	96.97	118	96.97	0	0.00	0	0.00	0	0.00	0	0.00	4	3.23	4	3.23
	2.	94	93.07	160	91.42	3	2.97	8	4.57	0	0.00	0	0.00	4	3.96	7	4.01
September	1.	183	79.23	183	79.23	40	17.32	40	17.32	0	0.00	0	0.00	8	3.45	8	3.45
	2.	196	80.34	205	74.82	42	17.21	57	20.80	0	0.00	0	0.00	6	2.45	12	4.38

A = Short term panel; B = Long term panel; a = Frequency of occurrence (%); b = Relative frequency of occurrence (%);
1 = Ist fortnight; 2 = IInd fortnight

After drying the panels, the fouling organisms were counted. Usual observations and scrapings of the rocks, wooden piles, and concrete structures were carried out to study the distribution of fouling species in in these areas. The results are summarised in Tables 1 and 2.

Results and Discussion

The fluctuation of salinity in the area was considerably high owing to the land drainage and precipitation and it was evident from the observed data that the salinity was one of the major factors influencing the nature and distribution of foulers. The fouling intensity varied in relation to salinity and was at the highest during pre-monsoon (32.62‰ at station 1 and 36.92‰ at station 2) and at the lowest in monsoon (1‰ at Kodibag and 1.02‰ at Baithkol). It has been found that even in the low saline waters, there was attachment of *Balanus* sp. at the estuarine station while there was complete absence of oysters, mussels and bryozoans during this period. But surprisingly, very little attachment of bryozoans was recorded at station 2. Based on these results, it can be said that *Balanus* sp. is considerably tolerant to the fluctuations of salinity in these waters except for a small variation in its abundance over the seasons.

The rapid attainment of sexual maturity in marine invertebrates under persistently high temperature is well known. Hence most of the fouling communities attained maturity after the monsoon, during September–November. With the fluctuation of about 4.5° C over the seasons in this area there was a corresponding fluctuation of 25.17% in the occurrence of fouling organisms.

It has been found that the oxygen content was low in the estuarine region (Table 3) whose interaction and cumulative effect with other factors minimised the attachment of oysters and avoided the fouling of *Perna*

Table 3. *Hydrological data in Kodibag (Station 1) and Baithkol (Station 2)*

		Salinity ‰		Oxygen ml/L		Temperature °C		Vertical extinction coefficient	
		St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2
March	1.	30.68	33.00	3.38	4.50	30.0	30.0	0.6331	0.9499
	2.	30.90	33.54	2.48	5.41	29.50	30.0	0.6331	0.6331
April	1.	31.72	36.01	1.35	6.42	30.0	30.5	0.9499	0.5429
	2.	32.10	35.42	1.46	5.41	30.0	30.5	0.6331	0.5429
May	1.	32.01	35.71	1.26	5.63	30.0	29.5	0.9499	0.2714
	2.	32.62	36.92	1.10	4.23	30.5	30.0	0.9499	0.2714
June	1.	32.74	33.14	2.37	7.52	30.0	27.0	1.2670	0.3166
	2.	28.03	18.10	3.49	7.21	16.0	26.0	1.9000	0.4750
July	1.	1.00	1.02	4.91	7.13	28.0	26.5	1.9000	0.9499
	2.	1.24	1.53	5.43	6.92	27.5	26.5	1.9000	1.2670
August	1.	2.61	3.01	6.01	5.81	25.5	27.5	3.1660	1.5830
	2.	2.73	3.45	5.25	5.91	27.0	27.0	3.1660	1.5830
September	1.	9.41	12.71	5.41	5.83	29.0	30.5	1.9000	1.2670
	2.	11.91	12.92	5.01	4.98	28.5	29.0	1.9000	1.2670

I = Ist fortnight; 2 = IInd fortnight

viridis on the panels. However, it is generally known that the dissolved gases and nutrients have a great effect on fouling organisms. Only a marginal fluctuation in oxygen content was observed at station 2 exhibiting the relative stability of the water column.

Turbidity increases due to silt, detritus and particulate matter in the medium, reducing the penetration of light and preventing the attachment of fouling organisms to a greater extent (Nair, 1965). Corresponding values of the extinction co-efficient are enumerated in Table 3. Turbidity increased considerably in the monsoon season and more so in the estuarine region because of heavy influx. The settlement of fouling organisms depended on the primary profile of micro-foulers, whose growth intensity in turn affected by high turbidity, prevented the colonisation of successive foulers on the panels.

Based on the tests conducted and results obtained, it was seen that the colour and texture of the substratum had great effect on the attachment of fouling community. Although rough glass panels provided a better substratum for the attachment of foulers, their grey colour affected the attachment but a relatively greater number of fouling organisms was noticed over the smooth and transparent glass panels.

In the fortnightly and monthly records of fouler settlement (Table 1 and 2) at least two variants of the *Balanus amphitrite* could be recognised. The oyster community on the panels, comprised of two species namely *Crossostrea madrasensis* and *C. gryphoides*. *Sebellaria spinulosa* and *Pomatoceros triquetor* were amongst the common polychaetes that were found interspersed on the panels, while bryozoans were represented by five dominant species namely *Bugula cucullata, Alderina arabianensis, Schizoporella cochinensis, Nolella papuensis* and *Bowerbankia imbricata,* the hydroids were composed of as yet unidentified species.

Except for a decline in the population during the monsoon season, the barnacles were found to occur throughout the period of study. Their attachment slowed on immediately after the monsoon and showed peak settlement during January–April.

During the monsoon season there was no attachment of oysters whereas in the premonsoon there was fairly good attachment at both the stations. The fouling intensity was more conspicuous on long term panels than on short term ones.

The settlement of bryozoans was heavy in the estuarine region during the pre-monsoon and was absent during the monsoon while at station 2 they were sparse.

The two species of polychaetes encountered in the Karwar waters were totally absent during the monsoon period with peak settlement in station 1 during the pre-monsoon while at station 2 they appeared only after monsoon.

The colonial hydroids were the predominant pioneer fouling animals which formed a base for the settlement of other fouling communities over the panels. The general trend of the two species encountered was increase during the pre-monsoon and decrease in the monsoon respectively.

The present study has taken into consideration, the intensity of fouling organisms during March–September. The stations studied were unique in the sense that there was heavy fluctuation in salinity and temperature (station 1) and moderate pollution caused by oil and dredging (station 2). The intensity of fouling ranged in relation to the hydrographical conditions. The number of fouling species occurring in the Karwar waters is very much less compared to other places along the Indian coast especially, Madras and Vishakapatnam. This may be due to more stable hydrographic conditions prevailing in the latter places. This may also be due to the lesser rain fall along the east-coast inshore than over the areas of the present study where the coastal waters are very much diluted on account of the ingress of freshwater. Similar results have also been obtained in the case of Cochin harbour (Cheriyan, 1966). Of the various species of fouling organisms *Balanus sp.* constituted the most important component of the fouling community of Karwar as was found for other regions.

The settlement period of barnacles at the different harbours revealed the following trends. While peak settlement occurred during April and May in Vishakapatnam, it was in May, and October to December at Cochin harbour (Nair, 1965). In Mangalore waters, the foulers were found to be abundant during the pre and post-monsoons (Menon & Nair, 1971) and as far as the experiments reveal, heavy settlement occurred during August–September in Karwar waters. However, the settlement of barnacles occurred throughout the period of study in the Karwar region. Occurrence of oysters was during April and May in Madras coast (Paul, 1942) and during August and September in Karwar while in Mangalore waters they settled throughout the year. The settlement of bryozoans along Karwar was during March, April and May whereas it was in July, August in Cochin. However, the settlement of polychaetes resembled that of barnacles and was found to decrease during the monsoon.

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NOTES

Echo Location of Fishes in Dhudawa Reservoir (Madhya Pradesh)

Based on observations in Mettur reservoir, Gulbadamov (1962) suggested that echo sounding would be a valuable aid in commercial fishing and fisheries research in reservoirs. Mitra & Durve (1978) advocated the use of asdic and other acoustic devices for assessment of reservoir fish population.

This investigation was aimed at locating fishes with echo sounder in Dhudawa reservoir, in Bastar district, Madhya Pradesh. The problem poised was that due to unprecedental rain in 1980, fishermen were neither able to catch fish from the known fishing grounds in this reservoir nor to locate any other fishing grounds. Therefore, to locate probable fishing ground, sounding was done with Furuno echo sounder model F.90. W; Type A having "White line" facility with ranges of 0–18–36–54 m. For recording 75 mm width dry paper was used. The echo sounder worked on 12 V battery.

Dhudawa is a medium irrigation reservoir built on the Mahanadi river system. The area at full reservoir level is 4403 hectares with a maximum depth of 20.8 m (68.75 ft.) The present rate of fish production is 5.28 kg/h.a. consisting of major carps.

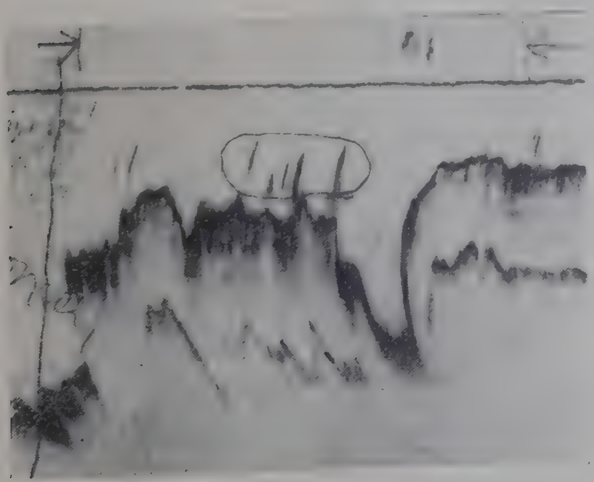

Fig. 1. Echograph showing fishes at off bottom

The echo sounder was operated from a row boat during February, 1981 and 17 observations were made in different locations. A track parallel to the river course, starting from the main dam and proceeding from lower to upper reaches was selected.

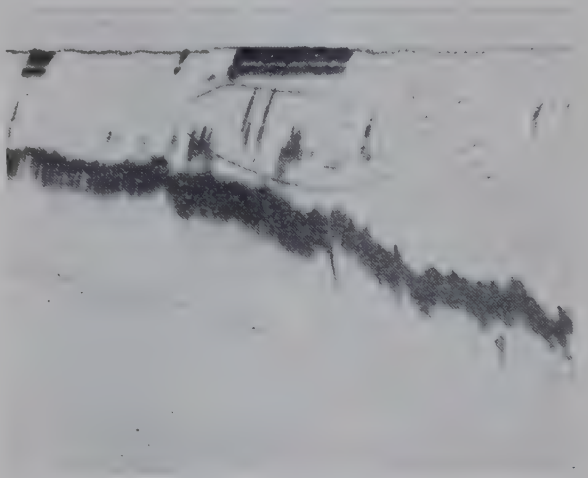

Fig. 2. Echograph showing fish at mid water

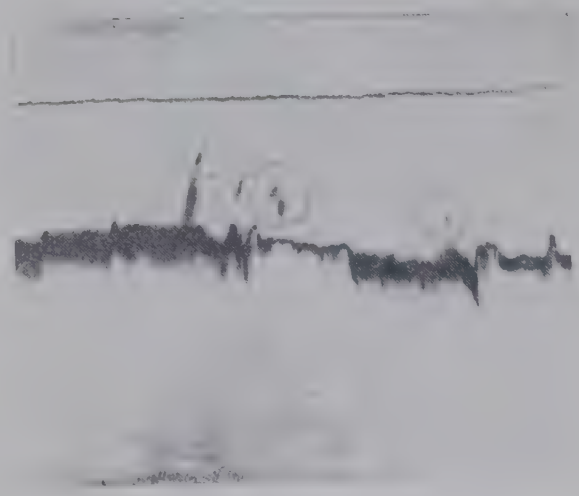

Fig. 3. Echograph showing stray fishes and shoals

In general, fishes were found to be distributed either towards off bottom or midwater areas. Thus in the early morning

in middle reaches, fishes were located off bottom at depths of 4.54–6.00 m. (15–20 ft.) (Fig. 1). Further as the day advanced, fishes were found to be distributed in mid-waters at depth of 3.03 m (10 ft) and off bottom (Fig. 2). During day in the upper reaches occurrence of single fishes in column waters at 1.51–3.03 m (5–10 ft) and shoals in the depth of 3.03–4.54 m (10.15 ft) were noticed (Fig. 3). Since echo location is a quick technique compared to other methods of fish location, it is desirable to introduce the same in other reservoir.

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Stick Held Drag Net for Shore Line Fishes of Reservoirs

Proliferation of shore line fishes in the reservoirs adversely affect the growth of commercially important fishes. Natarajan (1976), David *et al.* (1969) and George (1971) recommended the use of stick held drag nets for capturing shore line fishes. Varghese *et al.* (1981) reported that these fishes constituted 25.4% of the total catch in Hirakud reservoir. Of the several methods tried to harvest the shore line fishes, stick held drag net was found most suitable.

The stick held drag net experimented was 20 m long and 1.75 m broad throughout with a uniform mesh size of 7 mm (bar). Bamboo sticks, 65 cm length are fixed at an interval of 60 cm to both head and foot ropes. 266 observations were made from April, 1977 to February, 1980.

The net was operated by two persons. One end was held on the shore by one man and the other end was payed out in a semicircular fashion by the other man. The net was hauled from both the ends. During the course of hauling the fishes were scared from both the ends by splashing water and the net was dragged close to the bottom. Finally, it was hauled by holding the sticks in quick succession, lifted up and the catch removed (Figs. 1 & 2).

Fig. 1. Hauling the net

Fig. 2. The net lifted up with the catch

Table 1. *Total number of fishes and their percentage*

	Number	Percentage
Gudusia chapra (Hamilton)	11898	64.07
Rohtee cotio (Day)	1370	7.39
Puntius sp.	726	3.89
Chela bacaila (Day)	179	0.96
Chela chela (Day)	800	4.36
Xenentodon cancila (Hamilton)	185	0.99
Ailia coila (Hamilton)	49	0.26
Cirrhinus reba (Hamilton)	213	1.14
Ambassis nama (Hamilton)	1959	10.56
Ambassis ranga (Hamilton)	896	4.82
Rhinomugil corsula (Hamilton)	116	0.62
Channa sp.	127	0.68
Mystus tingra (Hamilton)	16	0.08
Callichorus pabda (Day)	34	0.18

Table 2. *Percentage intensity of dominant species during djfferent seasons*

	Pre-monsoon		Monsoon		Post-monsoon	
	No.	Percentage	No.	Percentage	No.	Percentage
Gudusia chapra (Hamilton)	4380	36.84	1671	14.04	5847	49.12
Ambassis nama (Hamilton)	417	21(27	213	10.89	1329	67.84
Ambassis ranga (Hamilton)	207	23.10	193	21.54	496	55.36
Rohtee cotio (Day)	179	13.07	1000	72.99	191	13.94
Chela chela (Day)	107	13.37	17	2.13	676	84.50
Puntius sp.	266	36.65	142	19.54	318	43.81

The percentage of fishes and seasonal abundance of dominant species are given in Tables 1 & 2. It is evident from Table 2 that *Gudusia chapra, Ambassis nama, Ambassis ranga* and *Puntius spp.* were maximum during post monsoon followed by premonsoon, whereas *Chela chela* was more abundant during post monsoon. This is consistent with the observations of Natarajan (1976). *R. cotio* was caught in large numbers during monsoon months.

The above observation indicates that stick held drag net can be effectively utilised for the removal of these fishes during their shore-ward movement in the respective period.

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